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Phase 1 Development Report for the SESSA Toolkit

Robert G. Knowlton, Brad J. Melton and Robert J. Anderson

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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Robert G. Knowlton, Brad J. Melton and Robert J. Anderson
Department 6632 – Chemical & Biological Systems

Sandia National Laboratories
P.O. Box 5800
Albuquerque, New Mexico 87185-MS0734

Abstract

The Site Exploitation System for Situational Awareness (SESSA) toolkit, developed by Sandia National Laboratories (SNL), is a comprehensive decision support system for crime scene data acquisition and Sensitive Site Exploitation (SSE). SESSA is an outgrowth of another SNL developed decision support system, the Building Restoration Operations Optimization Model (BROOM), a hardware/software solution for data acquisition, data management, and data analysis. SESSA was designed to meet forensic crime scene needs as defined by the DoD's Military Criminal Investigation Organizations (MCIO). SESSA is a very comprehensive toolkit with a considerable amount of database information managed through a Microsoft SQL (Structured Query Language) database engine, a Geographical Information System (GIS) engine that provides comprehensive mapping capabilities, as well as a an intuitive Graphical User Interface (GUI). An electronic sketch pad module is included. The system also has the ability to efficiently generate necessary forms for forensic crime scene investigations (e.g., evidence submittal, laboratory requests, and scene notes). SESSA allows the user to capture photos on site, and can read and generate barcode labels that limit transcription errors. SESSA runs on PC computers running Windows 7, but is optimized for touch-screen tablet computers running Windows for ease of use at crime scenes and on SSE deployments. A prototype system for 3-dimensional (3D) mapping and measurements was also developed to complement the SESSA software. The mapping system employs a visual/depth sensor that captures data to create 3D visualizations of an interior space and to make distance measurements with centimeter-level accuracy. Output of this 3D Model Builder module provides a virtual 3D "walk-through" of a crime scene. The 3D mapping system is much less expensive and easier to use than competitive systems. This document covers the basic installation and operation of the SESSA toolkit in order to give the user enough information to start using the toolkit. SESSA is currently a prototype system and this documentation covers the initial release of the toolkit. Funding for SESSA was provided by the Department of Defense (DoD), Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) Rapid Fielding (RF) organization. The project was managed by the Defense Forensic Science Center (DFSC), formerly known as the U.S. Army Criminal Investigation Laboratory (USACIL).

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SUMMARY

This report details the efforts involved in developing a new crime scene and Sensitive Site Exploitation (SSE) toolkit. The toolkit is called the Site Exploitation System for Situational Awareness, or SESSA. Topics covered in this report include:

- An overview of a requirements specification for a crime scene device prepared by members of the Military Criminal Investigation Organizations (MCIO).
- An overview of an existing decision support system for data acquisition, data management, and data analysis that supplied the basis for much of the SESSA toolkit. The system is called the Building Restoration Operations Optimization Model, or BROOM.
- An overview of the functionality of the SESSA system for crime scene data acquisition and documentation.
- An overview of a novel 3D model builder system to create virtual 3D walk-throughs of indoor spaces as well as a measurement tool.
- Highlights of a SESSA training and evaluation venue held at the Federal Law Enforcement Training Center (FLETC).
- Recommendations for future work.
- An appendix containing the user's manual for the current system.

The MCIO requirements included a hardened tablet computer with a touch-screen display that runs under the Windows operating system. The tablet has the ability to run other Windows-based software that crime scene investigators require, thereby making it a stand-alone computer platform for investigators. The SESSA software meets most of the MCIO needs for documenting crime scene investigations, including the ability to create sketches, maps, and auto-generating forms. The system allows multiple users to share information from a crime scene. The 3D model builder has tremendous potential for documenting indoor crime scenes with both visual and depth measurement capability. The 3D model builder is very affordable, utilizing a visual-depth sensor that costs only \$150. Processing of the sensor data is done with unique algorithms that allow the system to function on a tablet computer that does not require a sophisticated Graphics Processing Unit. Other 3D visual-depth systems cost upwards of \$65K to \$100K. The system is currently a functioning prototype. Recommendations for future work include: the development of a work-flow logic in the SESSA software to make the documentation of crime scene activities more intuitive; enhancement of the 3D model builder software to improve the visual output; the ability to share the 3D model builder output with persons remote to the crime scene in order to provide them situational awareness.

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1. Introduction

The Site Exploitation System for Situational Awareness (SESSA) is a decision support toolkit to aid in forensic crime scene investigations and with Sensitive Site Exploitation (SSE) data acquisition and reconnaissance. SESSA was developed by Sandia National Laboratories (SNL), with funding from the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) Rapid Fielding (RF) organization. The project was managed by the Defense Forensic Science Center (DFSC), formerly known as the U.S. Army Criminal Investigation Laboratory (USACIL), within the Department of Defense (DoD).

The SESSA toolkit builds off of an existing data acquisition, data management, and data analysis system called the Building Restoration Operations Optimization Model (BROOM). BROOM (Knowlton et al., 2012) was designed for consequence management activities (e.g., characterization sampling, decontamination monitoring, and clearance sampling for re-entry) following chemical, biological and radiological releases. SESSA was designed to meet the stated needs of the Military Criminal Investigation Organizations (MCIO). Members of MCIO include the U.S. Army Criminal Investigation Command (USACIDC), the U.S. Air Force Office of Special Investigations (USAFOSI), and the Naval Criminal Investigative Service (NCIS). Many of SESSA's features are captured from SNL's BROOM system, which has been in use for over seven (7) years, including over \$2M worth of development with Department of Homeland Security (DHS) and Department of Energy (DOE) funding. Previous investments from other agencies in the BROOM system are considered leveraged funds toward the development of SESSA, due to the dual-utilization of methods for both products.

SESSA is currently configured for a hardened tablet computer that can be used by agents and warfighters for rapid data acquisition, map generation, automated electronic forms, and help files. The hardened tablet computer can be sanitized between uses to preclude any contamination of crime scenes from one to the next. The initial tablet computer selected by the MCIO participants is a Panasonic H2 model that has an Intel i5 chip set running Windows 7, so it is capable of being a single use platform for an agent. The system allows touch-screen utilization. The SESSA software will also run on other Windows-based tablet computers. A rapid, inexpensive 3D mapping system capable of making real-time scene measurements to centimeter-level accuracy has also been added to the system.

The SESSA toolkit is user-friendly, less time-consuming, less costly, with a smaller equipment footprint, than conventional approaches to this need set.

2. Methods, Assumptions, and Procedures

The SESSA toolkit is a very comprehensive package for collecting and managing crime scene and sensitive site data. Many of its features derive from the BROOM system. There may be as much as 80% of the SESSA functionality coming from the BROOM platform. Therefore, SESSA is definitely a leveraged effort.

2.1 MCIO Needs for a Crime Scene Device

The BROOM system was not designed for forensic crime scene use or SSE needs. Therefore, enhancements were in order to meet the needs of the forensic community. The MCIO had key representatives meet to define the needs for the SESSA toolkit. Table 2.1 has a listing of the needs identified for a crime scene device, as well as additional information on prioritizing those needs.

Need	Priority	BROOM	SESSA	Notes
Use at scene with or without connectivity	1	✓	✓	
Easy to maintain	1	✓	✓	
Few clicks for evidence entry	1	✓	✓	
Minimal components with capability to expand (USB/Bluetooth)	1	✓	✓	
Full keyboard & > 10" screen	1		✓ -	SESSA - 10" screen with touchscreen keyboard, could add USB keyboard or docking station
Initiates barcode assignment/chain of custody	1	✓	✓	
Multi-functional (references/manuals/video library)	1		✓	
Windows OS (iOS depending and what it would support)	1	✓	✓	
GPS enabled/capable	1	✓	✓	
CAC enabled	1		✓	
Takes overall scene notes	1	✓ -	✓	BROOM captures consequence management data but not forensic data
Creates 2D (w/ ScenePD Pro) and 3D sketches or maps	1	✓ -	✓	BROOM - can create maps with polygons or import maps; SESSA - has sketch pad, allows import of ScenePD Pro maps, and can generate 3D imagery
Selected scene info sent to lab	1		✓	SESSA will sync with an LIMS in future version, need LIMS specs
Ability to create notes to document changes	1	✓ -	✓	BROOM - can input notes but not as a change feature per se
Ability to transfer to another agent and capture signature on chain of custody	1	✓	✓	
Generates necessary forms/documents: Receipts (custody document); Reports and lists; Laboratory submission forms; Disposition forms	1	✓ -	✓	BROOM - auto-generates chain of custody forms but not MCIO forms
Annotate photos	1	✓	✓	
Bar code scanner	1	✓	✓	
Wi-Fi / Bluetooth enabled	1	✓	✓	
Multiple units on scene / master and slave	1	✓	✓	
Have stylus capability (draw, sign, notes, etc)	1	✓	✓	
Weigh about the same as a laptop but not greater than	1	✓	✓	
Durability (Mil Specs; or, dust & water resistant, shock resistant, temperature ranges)	1	✓	✓	
Long battery life (unless onboard no proprietary batteries)	1	✓	✓	SESSA has on-board proprietary battery, 2 hot swappable batteries with 6.5 hour battery life
Camera w/ live video feed capability	2	✓ -	✓	BROOM has camera but not live video
Measuring device ± a few cm in 30m	2	✓ -	✓ -	BROOM - patented indoor positioning method accurate to a few cm in 10m; SESSA - 3D model builder accurate to a few cm in 4m
Unit to communicate with HQ, RBOC and lab (FAD and FXD)	2	✓	✓	

Table 2.1 – MCIO Crime Scene Device Needs

2.2 SESSA Crime Scene Toolkit

The SESSA system is intended to meet the needs of the forensic community as the primary component for a crime scene device, and later a SSE device. The system is not intended to include sensor capabilities at this time. The primary functionality of the toolkit is to capture and organize data for potential future use in criminal trials. The requirements for the system may be summarized as follows:

- Electronic capture of data, including barcode IDs
- Photo documentation
- Accurate locations of items of interest, both indoors and outdoors
- Accurate measurements of physical dimensions of a scene
- Ability to construct accurate building drawings
- Tracking of data
- Analysis of data
- Transparent record of all data and analysis
- Secure networking
- Evidence Receipt Forms, chain-of-custody forms, and report generation
- Real-time situational analysis for decision makers

There is a desire to have a hardware platform that is hardened (e.g., dust-proof, water-proof, shock resistant, etc.) for ease of use and sanitization if potentially compromised by biological, chemical or radioactive contamination. There is a preference to have a tablet-style computer with a 10 inch screen. The system should run the Windows operating system in order to utilize some existing software packages that assist with mapping and computer/cell phone interrogation.

Constructing accurate facility maps and determining accurate indoor positioning of samples and evidence are particularly time consuming activities. There is a need to streamline methods to acquire these types of spatial data, given the labor involved with conventional approaches. Therefore, SNL has developed an innovative sensor system to construct 3-dimensional maps that will allow users to interact in a scene walk-through mode and to measure distances within a crime scene. This same system can streamline the acquisition of room measurements in order to construct a building layout map more efficiently than with conventional measurement approaches (e.g., tape measures, laser rangefinders).

Hardware Platform

BROOM was developed for PC computers and currently runs on 32-bit Windows 7 and Windows XP operating systems. Part of the data acquisition paradigm for BROOM has been the use of a hardened PDA and a laser rangefinder that parses data to a laptop computer through wireless connectivity or a USB connection. The laser rangefinder was used in BROOM to provide accurate indoor x, y, z location coordinates using a patented method developed by SNL. For SESSA, there is an expressed customer need to have the system function on a hardened tablet computer that has an Intel i-series chip in order to support running other complementary software packages and to provide significant processing capabilities. By putting the system on a

tablet computer, the need for a separate handheld device for data acquisition goes away, thereby making wireless communication less of a challenge. Android-based tablets have been discounted from consideration due to the difficulty with programming significant processing capabilities into the platform. Apple iPad-based applications were discounted from consideration due to perceived security issues, such as the lack of CAC credentialing, limited processing power, and lack of ruggedness.

Several hardened tablet computers meet some of the basic needs for SESSA, including models from Panasonic, Armor, Motion, and Xplore. Panasonic's Toughbook H2 tablet computer appears to be the best fit relative to technical features, and is on both a GSA and Air Force purchasing schedule that allows easy procurement. The MCIO representatives requested that the SESSA toolkit be optimized for the Panasonic H2 tablet. The H2 has the following attributes:

- 10.1" sunlight-viewable dual touch LED (touchscreen and digitizer) screen
- Intel® Core™ i5-2557M vPro™ Processor, 1.7GHz with Turbo Boost up to 2.7GHz, Intel® Smart Cache 3MB
- Intel® QM67 video controller, max 1563MB shared VRAM with 32-bit
- 4GB SDRAM (DDR3-1333MHz), expandable to 8GB
- 320GB 7200rpm hard drive (shock-mounted and flex-connect) and hard drive heater
- Wireless features, including Wi-Fi, Bluetooth® and optional embedded 4G LTE or 3G Gobi™ mobile broadband
- Intel® Core™ i5 vPro™ Processor
- Sealed Fanless All-weather Design
- Sunlight-viewable Up to 6000 Nit in Direct Sunlight
- USB, Serial and Ethernet Ports
- Long-life Hot-swappable Twin Batteries Provide Limitless Hours of Use
- Available Built-in Camera, RFID and SmartCard and Barcode Readers
- MIL-STD-810G certified (6' drop, shock, vibration, rain, dust, sand, altitude, freeze/thaw, high/low temperature, temperature shock, humidity, explosive atmosphere)
- IP65 certified sealed all-weather design
- Magnesium alloy chassis encased with polycarbonate
- Integrated handle and ergonomic rubber hand strap
- Reinforced locking port covers
- Security

- Authentication: LEAP, WPA, 802.1x, EAP-TLS, EAP-FAST, PEAP
- Encryption: CKIP, TKIP, 128-bit and 64-bit WEP, Hardware AES
- Twin hot-swappable Li-Ion battery packs, 7.2V, typical 3400mAh, minimum 3200mAh each battery, battery operation: 6.5 hours (with both batteries), battery charging time: 3 hours on AC adaptor
- Password Security: Supervisor, User, Hard Disk Lock
- Kensington cable lock slot (on optional cradle)
- Trusted platform module (TPM) security chip v.1.2
- Computrace® theft protection agent in BIOS9
- Intel® Anti-Theft Technology
- Fingerprint reader
- Insertable SmartCard reader
- Contactless SmartCard reader
- 10.8"(L) x 10.6"(W) x 2.3"(H)
- 3.5 lbs. (with handle, strap and both batteries)
- GPS receiver (optional)
- 3MP camera with auto focus and LED light
- Barcode reader

In addition to the computer hardware, another piece of electronic hardware has been integrated into the system: an RGBD (red, green, blue, depth) sensor, or visual-depth sensor, made by ASUS. This is basically the same sensor as the Microsoft Xbox 360 Kinect gaming sensor. The visual-depth sensor will provide a 3-dimensional (3-D) scene capture function, together with custom software defined later in this document. The visual-depth sensor connects to the Toughbook via a USB connection. An Xbox game controller is also needed to control the interface of the 3-D model builder software.

Software Build Environment

The BROOM software is built with a .Net framework using C# for Graphical User Interface (GUI) functionality as well as some of the analytical processing. There are also some FORTRAN codes that are employed for some of the analysis features of the system. SESSA will build off of these same principals. The visual-depth sensor 3-D functions have been implemented using a gaming engine (i.e., Unity 3D). SNL utilizes the Subversion (SVN) source control system to maintain version control of all software development.

Graphical User Interface

BROOM has a fairly modern look and feel to the GUI, much like most Windows software with drop-down menus and icon-based activation for often-used functions. A Geographical Information System (GIS) is embedded in BROOM and the mapping window and controls take up most of the screen (see Figure 2.1). There is also a pane for accessing scenario information as well as reviewing some of the data within the Microsoft SQL database. SESSA will retain many of the same functions of the BROOM system, but will have a totally redesigned interface.



Figure 2.1 – Screen shot of the BROOM desktop software

The SESSA system uses a different foundation for developing the GUI screens. Instead of using Windows Forms, as was done when building the BROOM GUI, SESSA uses Windows Presentation Foundation (WPF). The use of WPF allows for a more modern look and feel to the SESSA GUI. Figure 2.2 shows an example of a SESSA screen. The SESSA system will allow touch screen functionality, including the use of a stylus.

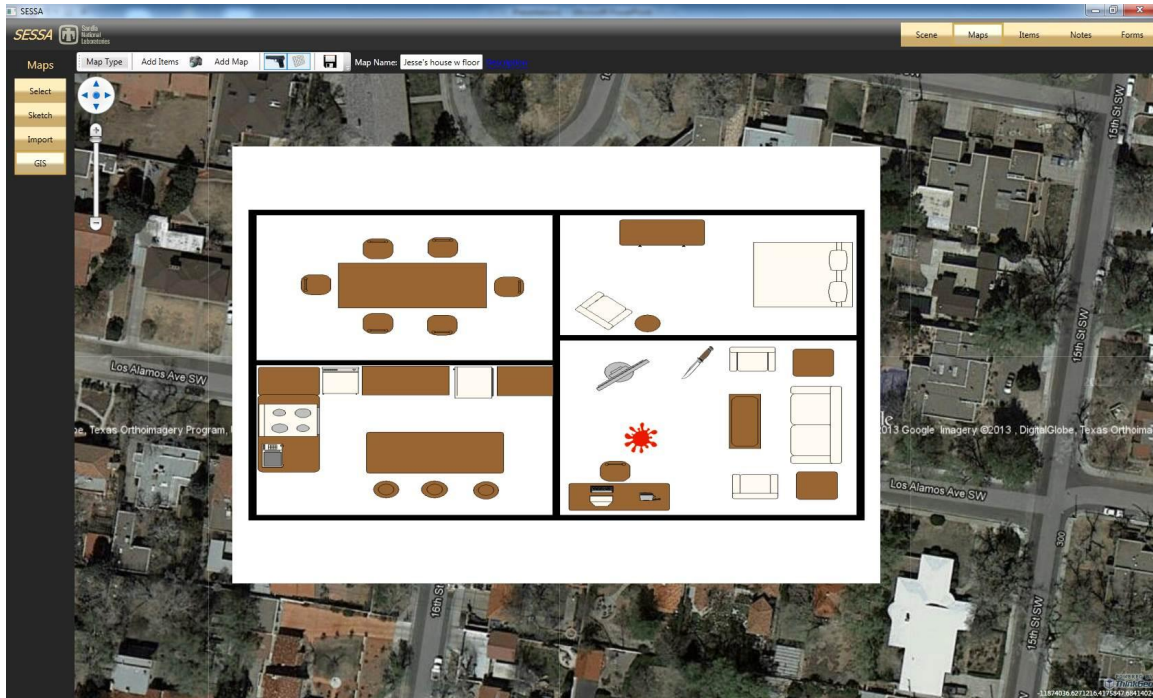


Figure 2.2 – Screen shot of the SESSA desktop software

The SESSA application has a GIS window that allows the use of Google maps and OpenStreetMap (with Internet connectivity), a stand-alone map kit with world-wide coverage, and the display of building maps. A separate module for sketching crime scenes also feeds visual information to the GIS window. A commercial software package called ScenePD Pro (by AT Solutions) can be utilized separately to develop building layout maps, the output of which can be displayed in the GIS window. Icons for photos, samples and evidence are displayed in the GIS window. In the future, a tool tip function will be invoked to provide some basic information on each icon when the user hovers over an icon with the cursor.

Data Acquisition Module

The data acquisition module draws upon elements of the BROOM PDA system. It is tied to the GIS mapping window for evidence and sample placement. The GUI was built with the WPF application, so it has a modern look and feel. The military has a step-wise process, or workflow, for collecting crime scene evidence and samples. Currently, the data acquisition module prompts the user for data associated with the case and the scene based on forms selected by the user. These are data that would identify the particulars of the crime scene investigation, including a military assigned case number. There is a need to document information about any people on scene or who have been at the scene. The scene description data are used as input to specific evidence forms, sample forms, and reports. The default evidence and sample types are consistent with those that the military is using in their property and laboratory databases. This data includes categories like firearms, DNA samples, electronics, etc. Within each category there are choices to add specificity, such as under electronics there are choices for computers, smartphones, thumb drives, etc. Barcoding and notes are essential elements tied to the evidence and sample data. There is a need to document any changes that a user may want to make

subsequent to original input. Documentation includes a note regarding the need for the change, the name of the person performing the change.

The Toughbook has a built-in 3 Mp camera. The camera can be used to take mid-range photos of a crime scene. It does not have the resolution to take the place of a digital SLR camera for more detailed crime scene photos. During development of the SESSA software, it was noted that Panasonic's process for acquiring photo imagery with the built-in camera was not consistent with the intended functionality of the SESSA software. SNL queried Panasonic regarding the intended use and Panasonic provided a suggested work-around.

The Toughbook has a barcode reader. SNL added a barcode generator to the software as well. The MCIO representatives requested this functionality. They anticipate that in the future evidence and/or samples could be barcoded with substantial scene information prior to shipping and then read on the receiving end for tracking purposes.

The methods used to collect evidence at a crime scene have been well documented by the U.S. Department of Justice in their publication entitled: "Crime Scene Investigation - A Guide for Law Enforcement" (USDoJ, 2012). Excerpts from this document have been inserted into the SESSA software as Help files for the user.

Whenever evidence is collected or samples need to be sent for laboratory analysis, a form needs to be filled out and accompany the item to its destination. The SESSA toolkit has the ability to auto-generate pdf forms for submittal with the evidence or samples. SESSA has the ability to capture electronic signatures for placement on the forms. The forms are saved electronically as pdf files. In future builds of SESSA, there is a desire to have data from the evidence and sample forms assimilated into an electronic file for ease of transferring that information into property and/or laboratory databases. The protocol for the data transfer still needs to be worked out with the MCIO, but they are aware of the need. The file may be an XML or .csv format.

GIS Module

In the BROOM system, the GIS engine was an ESRI product called MapObjects. It has been years since ESRI has supported this product. It is quite antiquated. As a result, the BROOM system had to perform many work-arounds to achieve its functionality. SNL decided to use a different GIS engine for the SESSA toolkit. The ThinkGeo GIS engine was built into SESSA. SNL's philosophy on building the software was to minimize licensing costs to the end user. SNL could have chosen a new ESRI GIS engine for SESSA, but the licensing costs would have been substantial to the end-users of the system. With ThinkGeo there is an up-front fee for each developer's seat but no end-user licensing. ThinkGeo provides the ability to use Google maps (including their satellite imagery) and OpenStreetMap when Internet connectivity is available. It also comes with a set of stand-alone maps for those occasions when internet connectivity is not available. The World Map Kit provides coverage throughout the globe.

Sketch Pad Module

In forensic crime scene investigations, there is much emphasis placed on sketching the crime scene, along with notes and annotation. This procedure helps build the body of knowledge for potential prosecution. The sketch pad module gives the user the ability to draw free-hand shapes with the stylus. There is also an eraser option to allow the user to edit their sketch. The sketch pad module saves the image as a bitmap format so that it can be used as another backdrop layer in the GIS engine. Figure 2-3 shows a screen capture of the sketch pad module in SESSA.

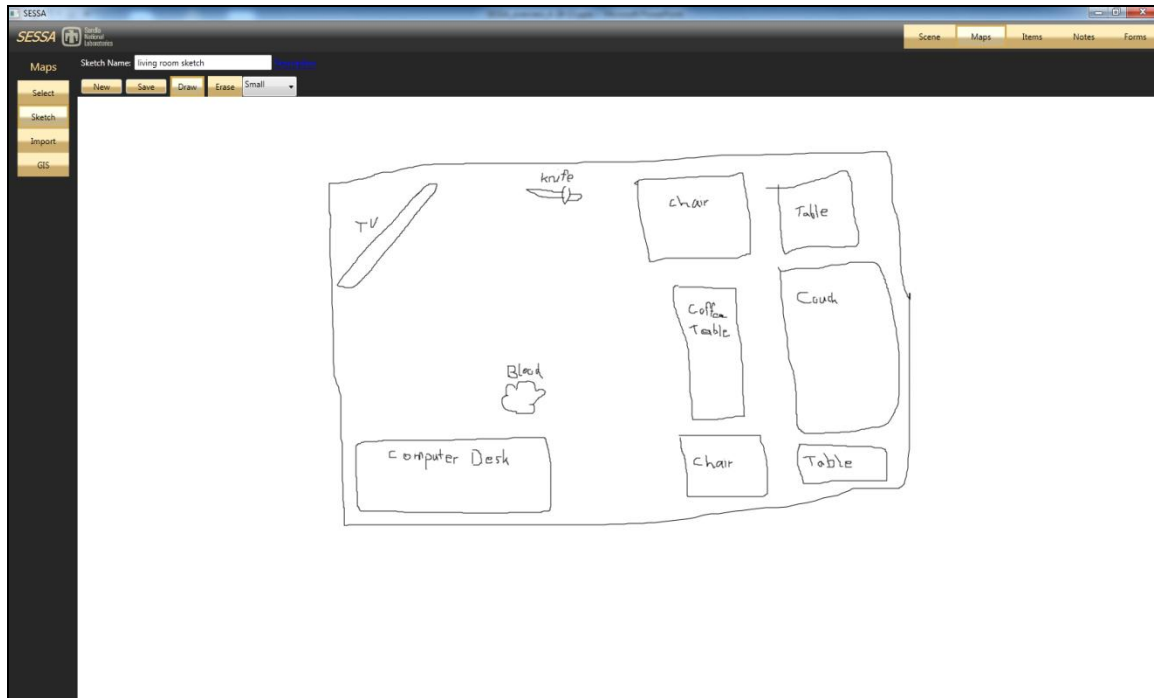


Figure 2.3 – Sketch Pad module in SESSA

ScenePD Pro

ScenePD Pro is a commercial package by AT Solutions used mainly to develop crime scene maps. The intent is to build accurate maps, not just sketch maps. This is part of the process of developing knowledge of the crime scene through time and data gathering. ScenePD Pro has the capability to add furniture to a map as well. Right now ScenePD Pro only outputs imagery as bitmap files. USACID, USAFOSI, and NCIS intend to keep using ScenePD Pro, rather than having SNL build a similar capability within SESSA. There is no need to duplicate this functionality within SESSA when the output of ScenePD Pro can be used directly as input to SESSA. So the paradigm for using SESSA will include the use of ScenePD Pro as a complementary software package that supplies imagery to SESSA.

Data Integration

The SESSA system should work on tablet computers running Windows, but has been optimized to work on Panasonic Toughbook H2 laptops, at the request of the MCIO representatives. There will likely be multiple agents investigating a crime scene. That said, there will be a need to combine the intakes from all of the Toughbooks at some point in the investigation, hopefully to one lead agent's computer. A crime scene will be assigned a unique number, so from a project standpoint each of the individuals could be logging data for the same project. Each agent could be assigned a unique identifier/name, if they do not have one already, so that there would not be any duplication of identifiers from one Toughbook to another. It is assumed that one of these individuals will be responsible for the basemap used by each agent so there is consistency in the spatial domain. It would be nice to share the final integrated data set amongst multiple users as well. A data integration option has been built into SESSA to facilitate this need.

User's Manual

A Quick Start User's Manual has been developed for the SESSA toolkit. This manual has been reproduced in its entirety as an Appendix for this report. The reader is encouraged to look through the User's Manual as it gives a good synopsis of the functionality of the toolkit.

2.3 SESSA 3D Model Builder System

The SESSA system also includes a new 3-D mapping and measurement system. Visual documentation of crime scenes is a critical need, and in recent years there have been advances in our ability to capture both 2D and 3D imagery. SNL has a cost-effective and innovative technique for 3D documentation of a crime scene that is arguably preferable to existing systems. In support of this claim, the information provided in a recent evaluation of panoramic photographic imaging and multidimensional laser scanner techniques by the National Institute of Justice (NIJ) are referenced (NIJ, 2013). These techniques provide a product that is basically a digital "walk-through" of a crime scene. The three panoramic imaging technologies selected for the NIJ evaluation were: (1) SceneVision-Panorama, (2) Panoscan MK-3, and (3) Leica ScanStation C10. The Scene-Vision-Panorama system provides 2D visual products but is not capable of providing measurements within the digital representation of the crime scene. The Panoscan and Leica systems provide 3D visual and depth/measurement capability. Figure 2.4 is taken from the NIJ report and shows the cost of these and other systems.

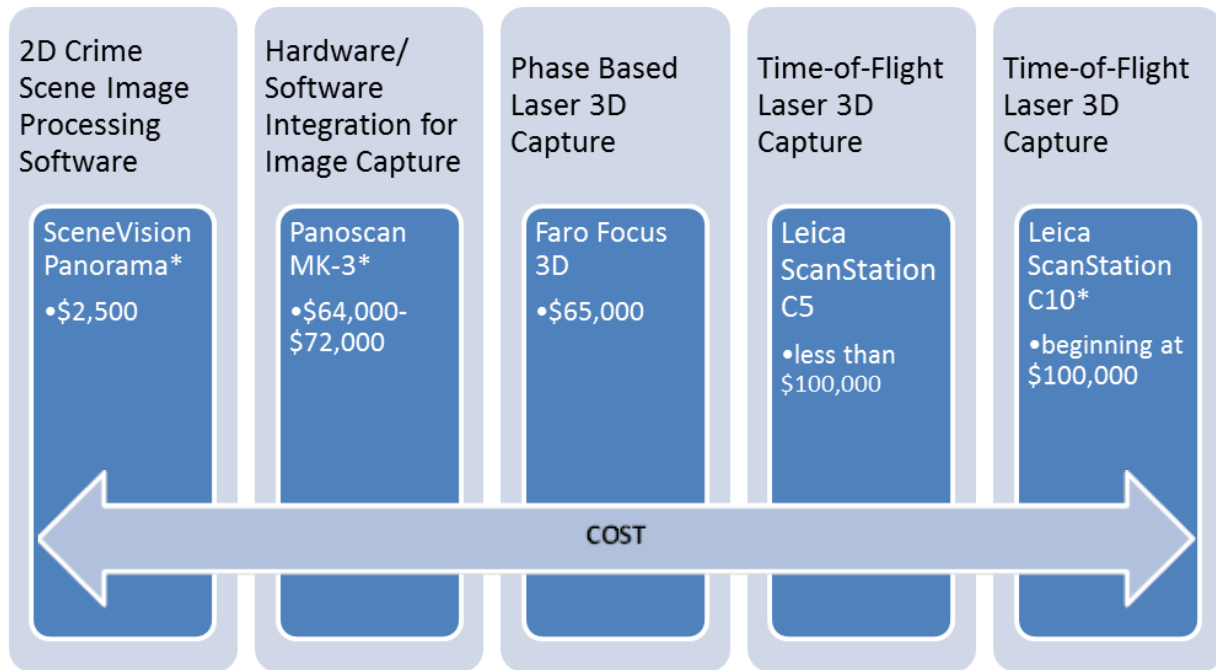


Figure 2.4 – 2D and 3D Panoramic Systems in Use for Crime Scene Investigations (from NIJ (2013))

A synopsis of the findings of this evaluation by the NIJ is shown in Figure 2.5.

	SceneVision-Panorama	Panoscan MK-3	Leica ScanStation C10
Strengths	<ul style="list-style-type: none"> • Cost-effective • Single agent operation possible • Crime scene units will already have most of the hardware • No special transport considerations • Easy to learn and use • Fast to deploy on scene • Third-party stitching software can be used 	<ul style="list-style-type: none"> • Data collection is “push button” • Single agent operation possible • Images are produced quickly on scene with minimal processing • Excellent photo quality • Few transport considerations • Third-party software can be used • No stitching is required 	<ul style="list-style-type: none"> • Measures large areas much faster than manually • Data-rich scene capture; millions of points measured • Unit can make measurements even when ambient light is too low for photography • Unit is weather resistant • Every element in the scene is measured • Removes operator bias from measurement
Weaknesses	<ul style="list-style-type: none"> • No automation • Operator must have strong basis of photography theory and photo composition • Scan times can take longer in low-light conditions because of photography requirements • Non-descript rooms or featureless open areas are difficult to stitch • Especially large scene files can tax older computers 	<ul style="list-style-type: none"> • Auxiliary light sources must rotate around the camera or they will appear as a starburst • Light source is sold separately, but is needed for low-light environments • Uneven lighting at scene requires additional software processing • Panometric photogrammetry system is inaccurate outside of 25 feet (not evaluated for this report) • Training is separate from purchase • High-resolution pictures can tax older computers 	<ul style="list-style-type: none"> • Slower than manually measuring for tight and small scenes • Comprehensive measurement times are greatly increased by clutter/debris/obstructions • Must have clear line of sight to document elements in scene • Requires training commitment • Not user friendly • Equipment is bulky and requires transport considerations • Large file size • Computer knowledge is a requirement to use and perform backend processing

***Figure 2.5 – Strengths and Weaknesses of the 3 Panoramic Systems
Evaluated by the NIJ (2013)***

One can see from Figures 2.4 and 2.5 that the 3D visual-depth devices are quite expensive and have significant weaknesses. The SceneVision-Panorama device does not have depth/measurement capability and is therefore deficient for that need. It is a good device for visual documentation, but not for the need to measure distances or sizes of objects in a crime scene. Therefore, a more cost-effective and user-friendly system is desired.

The SESSA 3D Model Builder System is formulated around the Microsoft RGBD (i.e., red-green-blue-depth), or visual-depth, sensor made for their Xbox 360 gaming system to capture live 3-D action in order to facilitate interactive play. Microsoft calls this the Kinect system. The sensor is a low-cost device, only \$150 from the manufacturer, ASUS. The sensor can capture a 640 x 480 mesh of RGBD signal in a 54° field of view in either still-frame or video (30 frames per second) modes. Freeware software exists to aid in processing this imagery to create 3-D representations, but it does not provide enough processing ability to create quality imagery for crime scene documentation so additional algorithms had to be developed to complement the freeware. SNL’s Robotics group has been utilizing this visual-depth sensor for some of their

project work related to autonomous control of robotic platforms while mapping interior spaces. The Robotics group has added additional functionality to the processing software. More changes were required to meet the mapping needs of the SESSA toolkit. The Robotics application uses the video capture method along with some serious processing techniques that employ a Graphics Processing Unit (GPU) with CUDA parallel processing architecture. The tablet platform selected for SESSA does not facilitate the use of a GPU or any advanced mathematical processing. Therefore, a novel approach was selected. The SESSA system utilizes overlapping still-frame captures and “stitches” the individual scenes together to create a 3-D representation of an indoor space. This “stitching” process is referred to as SLAM, or Simultaneous Localization And Mapping. In this manner, the processing can be done on a tablet computer running an Intel chip in real time. The SESSA 3-D mapping and measurement system facilitates measurements within a scene with centimeter-level accuracy in the near field (to about 4 meters distance) and provides spatial data to aid in the construction of building layout maps. The Unity 3D gaming engine is used to build a complementary software module to accomplish the goals of the 3-D mapping and measurement system.

The 3D Model Builder application utilizes the visual-depth sensor, mounted into a custom bracket that also houses the Toughbook tablet computer and is affixed to a tripod. An Xbox controller is also desirable to navigate the 3D virtual space created by the application. Figure 2-6 shows the setup. The current paradigm for capturing a 3D scene is the user sets up the tripod in the room of interest. Still frame shots are taken by rotating the device 45 degrees for each still-frame shot as the sensor traverses around the room, for a total of eight shots. Then the device is tilted upward at a 30° angle and the process repeated. Then the final step is to tilt the device down 45° and repeat the process. Once these 24 still frames have been taken the user renders the scene into a 3D representation. This process takes approximately 10 minutes to complete. Once complete the user can select a mode in the software that allows them to measure the distance between two points in the 3D virtual world. These points could be the width and length of the room, for instance, in order to facilitate drawing accurate maps of the facility when using the ScenePD Pro software. It can also be used to measure distances between objects of interest in the crime scene.



Figure 2.6 – 3D sensor and tablet configuration for SESSA

In the future, it is hoped that the system will be extended to offer true 3-D walk-through rendering capability and a more streamlined approach to developing building layout maps. Also, the 3-D mapping module will need to share measurement and room dimension data with the main SESSA software package. In the future, SNL hopes to integrate some of the functionality of the data acquisition module into the 3D rendered scene to facilitate data entry in the 3D virtual world. The Unity gaming engine can supply executables that can be run on multiple platforms, such as Windows, Android (for smart phones and tablets), as well as Apple iPads and iPhones. Therefore, another future build could have smartphones and tablet computers all sharing the 3D representations of the crime scene and facilitating data entry into that 3D world. This type of visual and depth information may be invaluable for court room presentations of a crime scene investigation.

2.4 Training and Evaluation at FLETC

A training and evaluation venue was held for the SESSA toolkit on May 14 and 15, 2013 at the Federal Law Enforcement Training Center (FLETC) in Glynnco, Georgia. SNL staff trained MCIO personnel from the Army, Navy and Air Force. FLETC has mock crime scene facilities. One of these facilities was used for training and evaluation of the system. Figure 2-7 shows the 3D Model Builder application in use in one of the mock crime scene rooms.



Figure 2.7 – Using the 3D Model Builder at FLETC

Figure 2.8 shows a screen shot of the 3D Model Builder for one of the mock crime scene rooms at FLETC.

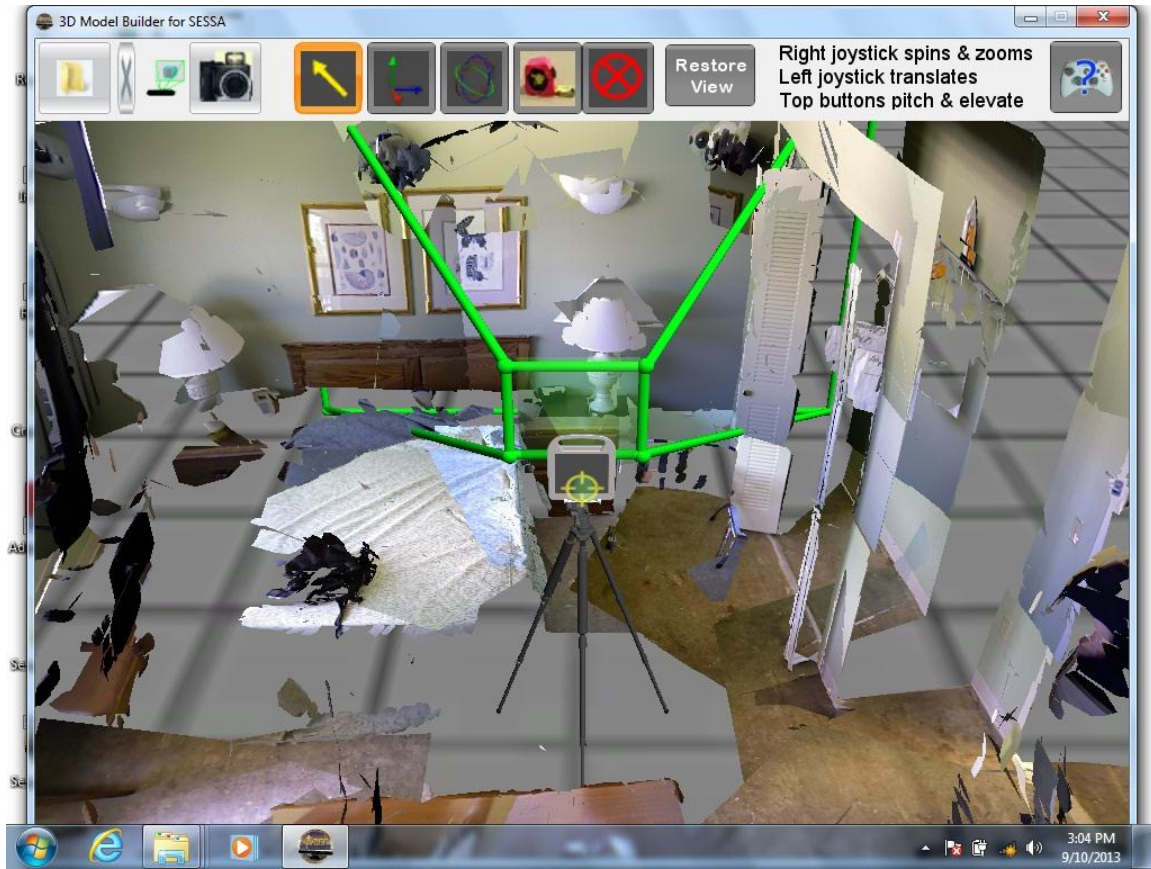


Figure 2.8 – Screen shot of the 3D Model Builder at FLETC

At the conclusion of the venue, a hot-wash was conducted to get candid feedback on the performance of the prototype SESSA toolkit. Some of the comments were as follows:

- A commercial software package funded by the FBI has a good workflow and interconnectivity between smartphones and tablets. The Air Force is looking at the possibility of adapting it for their use for data collection. It does not do the 3D scene capture like SESSA does.
- Would like SESSA to have audio/video conferencing amongst agents, both on-site and off.
- Blood splatter and trajectory analysis, as well as hyper spectral imaging for biological analysis on scene is desired. Other software is available for these needs. Might consider coupling an imaging device with the 3D sensor.
- Would like to use an infrared thermometer and ability to take temperatures from different items.
- Would like to be able to do activities such as interviews and then remotely watch the video.

- Would like a means of reminding agents about field testing protocols and to prompt the user for what you are going to do with the item. Do you want to test for blood? Problem will be to keep the information current as it is perishable.
- Might consider keeping product lists with web site addresses.
- Would like to link/integrate a 3D object into the GIS, for example like is done with a 2D object (photo).
- Need to keep cost down as much as possible. Unit of issue will be by office and size and not unit of issue for each agent.
- The 3D Model Builder system has great potential. Competing systems are either markedly more expensive and non-rugged, or do not meet all of the needs (i.e., combining visual and distancing information with the appropriate measurement accuracies). Would like the 3D Model Builder to have less reliance on a tripod and have the ability to capture imagery throughout the room to build a fully 3D representation of a scene. Want this technology to take the place of the camera stitching visuals and the tape measure/laser rangefinder measurement techniques. If working as desired, it would save considerable time and effort in documenting a crime scene. If the 3D rendering could be shared with other agents off-site it would greatly facilitate direction given to on-site personnel. With the appropriate clarity it could also be used for litigation.

3. Results and Discussion

ASD(R&E) provided funding to SNL to build a forensic crime scene device and SSE tool. The toolkit is called the Site Exploitation System for Situational Awareness, or SESSA. SESSA leverages techniques from a previous \$2M+ effort that resulted in the Building Restoration Operations Optimization Model, or BROOM, a data acquisition, data management, and data analysis package. Funding for BROOM was mainly from DHS. The funding for SESSA was intended to produce a TRL Level 6 prototype.

SESSA delivers on many of the needs identified by MCIO for a crime scene device and SSE tool. SESSA is optimized to work on a hardened touch-screen tablet computer running Windows software (optimized for a Panasonic Toughbook H2). Several Toughbooks were procured and delivered to DoD with the SESSA toolkit. SESSA facilitates data entry, automated forms generation, barcode generation and scanning, photos, as well as 3D scene rendering capability using a novel visual-depth sensor approach.

The Toughbook has a couple of issues that need to be addressed. First, the utilization of the on-board camera was problematic. The camera can only be accessed once to take a photo for a given initialization of the camera. A subsequent photo will crash the software. Panasonic was contacted and acknowledged the deficiency as one they were aware of. They offered a method to work around the problem. This may be problematic in the future. Second, three of the Toughbooks had an issue when they were in a low-battery power state. The Toughbooks reset themselves to a prior saved state. This prior saved state did not have the SESSA software. The identified solution involves utilizing the recovery disk that comes with the Toughbook to re-initialize the system followed by a re-installation of the SESSA software. Panasonic was notified of this issue and never responded.

There are other hardened laptops running Windows (e.g., Motion F5t) that might be considered as an alternate platform for the system. The Motion device has a couple of additional features that have been mentioned as desirable. It has two cameras, one on the front and one on the back, making it more amenable to live video-conferencing. It has an RFID reader as well.

A training and evaluation event was held in May 2013 at the FLETC in Glynnco, GA. Several members of MCIO were in attendance to receive the training and to perform the evaluation. SESSA was evaluated in mock crime scene venues at the site. A hot-wash provided feedback for enhancements to the toolkit as well as direction for future efforts. The recommendations from the group were very valuable. The MCIO personnel were most enthusiastic about the 3D model builder capability, which could eventually take the place of much of the existing photo documentation of mid-scene visual data capture as well as replacing the time-consuming measurements that are performed with tape measures and laser range finders.

Eventually all of the referencing of crime scene evidence might be performed in a virtual 3D scene construction, which could be shared remotely with others. Nothing like this exists today at the cost-point that is targeted for the SESSA system.

4. Conclusions

The first phase of building a TRL 6 prototype crime scene device and SSE system was a success. The SESSA toolkit delivers on most of the priority 1 needs identified by the MCIO. A training and evaluation event took place at FLETC. This, too, was a success. Definitive feedback was generated that can be used as criteria for possible phase 2 funding to enhance the system and bring it closer to a fielded product. A key outcome of the evaluation is the recognition that the 3D model builder module of SESSA has great potential to streamline some of the more time consuming aspects of a crime scene investigation. The 3D model builder provides visual and depth data at a much lower price point than competitive technologies.

5. Recommendations

A number of recommendations for future enhancements of the SESSA toolkit were made as a result of the training and evaluation venue at FLETC in May 2013. In addition, there are stated MCIO requirements for a crime scene device that should be addressed. These recommendations can be summarized as follows:

- The 3D model builder module should be improved in the following manner:
 - Less reliance on the tripod to capture initial imagery
 - Better ‘stitching’ of the visual-depth information to form a 3D rendering of a crime scene
 - Ability to quickly fill in “gaps” or “occlusions” in the 3D image by walking around and capturing additional images in real time
 - Ability to add evidence information directly into the 3D rendered imagery, as well as providing notes
 - Ability to quickly define the geometry of the room layout and have it translated to a 2D map of the facility, including the possible use of this method to define hidden spaces in a facility
 - Ability to share a 3D rendered crime scene remotely in near real time
- Another visual-depth sensor configuration should be considered (an alternative to the Kinect-style sensor which has a limitation of 4m) in order to meet the stated need of cm level accuracy out to 30m. A combination laser-camera setup might be configured for less than \$10K in hardware costs. Similar systems, with software, cost on the order of \$65K to \$100K. This device would need to be rugged and also put to use as an SSE tool. SESSA should be built with flexibility to the needs of the user, where the Kinect-style sensor is applicable for some uses and a laser-based device suitable for other uses.
- The SESSA crime scene software should be modified to include a workflow component.
- The Help system should include ‘how to’ videos, in addition to the pdf help files.
- Consideration should be given to an alternative tablet computer, as the Toughbook has some issues
- The data acquisition module should be ported to an Android operating system in order to allow smaller hardened tablets and smartphones to be used to collect data and to integrate the data to a master dataset
- Develop an data export feature to quickly share information with a laboratory and/or property database (need specifications for data elements to be shared)
- Evaluate SSE requirements and build a version of SESSA to meet these needs
- Consider an ability to interface with a USB thermometer
- Consider an ability to use the 3D model builder module to assist with blood splatter analysis

- Consider an ability to use the 3D model builder module to assist with trajectory analysis
- Consider adding hyper-spectral imaging for biological analysis to the 3D model builder module

Additional testing would need to be conducted if any of these enhancements are pursued, with the goal of fielding the system for routine use within the MCIO, SOCOM and other organizations that could benefit from this SESSA toolkit.

6. References

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APPENDIX

USER'S MANUAL FOR SESSA TOOLKIT

1. AN OVERVIEW OF THE SESSA SYSTEM

1.1. Overview

The Site Exploitation System for Situational Awareness (SESSA) is a decision support system to aid in forensic crime scene investigations and with Sensitive Site Exploitation (SSE) data acquisition and reconnaissance. SESSA was developed by Sandia National Laboratories (SNL) with funding from the U.S. Army Criminal Investigation Laboratory (USACIL) within the Department of Defense (DoD).

The technical needs for SESSA were identified by members of the DoD's Military Criminal Investigation Organization (MCIO). The main needs are classified as follows:

- Electronic capture of data, including barcode IDs
- Photo documentation
- Accurate locations of items of interest
- Accurate measurements of physical dimensions of a scene
- Ability to construct accurate building drawings
- Tracking of data
- Transparent record of all data and analysis
- Common Access Card (CAC) enabled
- Forms and report generation
- Help system for evidence collection
- Real-time situational analysis for decision makers

The custom SESSA software is optimized for a hardened tablet computer running the Windows 7 operating system, capable of running other complementary software products, thereby making it a complete system for forensic needs. The current tablet computer used for SESSA is a Panasonic Toughbook H2 model. The SESSA software functions on other Windows 7 platforms but some of the functionality may not work properly, such as utilizing the on-board camera for photographs. The SESSA system also employs a unique 3D scene capture system using a visual/depth sensor that is capable of accurate scene measurements with centimeter accuracy. Code for the 3D scene capture is separate from the SESSA code, but is complementary.

Mapping

A picture is worth a thousand words. SESSA includes several options for documentation of spatial information. SESSA uses a Geographical Information System (GIS) engine to manage map layers. This embedded product is from ThinkGeo (<http://thinkgeo.com/>). There are no GIS licensing fees for users of the SESSA system, unlike some prominent GIS solutions that charge substantial yearly licensing fees.

The SESSA system has the following tiered approach to spatial mapping and display:

- First tier is a sketch pad capability using a stylus;
- Second tier allows the user to use ScenePD Pro, by AT Solutions, to make maps and import into SESSA; and
- Third tier allows the use of Google maps and stand-alone maps, and can integrate with first and second tier map products.

In the third tier mapping module, the user can place icons for evidence collection and associate appropriate forms and notes to each. Forms can be modified until the user wants to finalize them and then they are locked down. The implementation of electronic forms for the forensic crime scene investigators should save considerable time on-site at an investigation.

Data Management

SESSA has a built-in database to manage evidence data, notes, pictures, etc. The database is a Microsoft SQL Server database. SESSA also has the capability to integrate separate scene data from multiple agents.

Help

SESSA has Help features that should aid the forensic investigator or SSE personnel in the performance of their duties. A guidance document produced by the Department of Justice (DoJ, 2012) provides comprehensive step-by-step procedures for crime scene investigations. This document is accessible from SESSA. Excerpts from the guidance document are available for specific activities, such as evidence collection techniques for trace evidence, fingerprints, etc. Another guidance document that provides specific procedures for evidence collection and preservation was developed by USACIL (USACIL, 2013) and is also available by SESSA.

Practical Application

The targeted end users of the system are forensic crime scene investigators and Sensitive Site Exploitation personnel gathering data and evidence at crime scenes and areas of interest to national security. Within the military there may be several thousand crime scene investigators that could potentially use this system within the Army, Navy and the Air Force. The SSE community might have hundreds more users as well. Whether there would be a civilian use of the system by law enforcement or fire personnel is yet to be seen, but there is potential.

1.2. The Database Engine

The SESSA toolkit utilizes a Microsoft SQL (Structured Query Language) Server database to manage the potentially large amounts of data in order to provide situational awareness. The database allows the association and tracking of notes, data and photos between like items. The database also allows SESSA to re-use redundant data from one form to another so the user does not have to re-enter information more than once.

1.3. The GIS Engine

SESSA has a built-in GIS engine that enables the user to display maps and other bitmap imagery. This includes the ability to interactively access Google maps, with options such as the road map view, a satellite view, and a hybrid view that basically combines the two. SESSA can also access OpenStreetMap, a free online road map service. SESSA also has a world-wide map kit that can be used anytime, even when the user does not have Internet connectivity. The scenes of

interest and impact details in map format. The GIS engine in SESSA can also allow the user to place bitmap imagery, such as a building map, onto the Google map, OpenStreetMap, or stand-alone map imagery. From this view the user can then place evidence icon imagery on the map in the appropriate spatial location. The user can then click on the evidence icons to select forms to fill out or notes.

1.4. Forms

SESSA offers the ability to create electronic forms. Currently there are forms for documenting agent activity summaries, agent investigation report, evidence/property custody document, forensic laboratory examination request, and a crime scene notes observer form. Other forms may be added in the future, depending on need. SESSA has custom user interfaces to fill in the information required for the various forms. Once the user is satisfied with the input to the forms, SESSA offers the option to finalize the form. The output is a PDF file in the official format sanctioned for the form. SESSA also allows the user to supply an electronic signature which is embedded in the PDF file as well.

1.5. 3D Model Builder System

SESSA has a complementary hardware/software solution set for generating 3-dimensional views of a crime scene with accurate spatial dimensioning. The system uses an ASUS visual/depth sensor, similar to the Kinect sensor used for Microsoft's Xbox 360 gaming system. The depth channel on the sensor is an infrared technology. The ASUS sensor has a USB connector to power the unit and transfer data to the Toughbook. The custom software runs in a Unity gaming engine and is controlled with an Xbox controller. The system can also be controlled with a mouse, but it is not as robust as the Xbox controller. The system can provide measurement capability with centimeter accuracy. The sensor is suitable for scanning to a distance of about 4 meters from the unit. Other experimental systems using the ASUS sensor capture data in a video format and process it with special Graphics Processing Unit chips. The SESSA implementation utilizes still-frame capture of imagery around a crime scene and stitches the imagery together for a 3-dimensional representation of the space. The algorithms that process this data are unique. The system has an algorithm to recognize flat plane surfaces, such as walls, ceilings and floors. The system is best used with a custom bracket mounted to a tripod that can control the movement of the sensor in specified increments as it scans the room. Once the user has captured a reasonable amount of the space in a room, a virtual walk through can be done. Distance measurements may also be made in near real time. The 3D Model Builder system can be used to measure the dimensions of a room as well, for map building purposes.

2. INSTALLING SESSA SOFTWARE

This section of the manual will guide you through installation of the SESSA software. You install the PATH/AWARE system from several DVD disks. First, you install PATH/AWARE on a desktop or laptop computer.

2.1 System Requirements

SESSA runs on most off-the-shelf computers. The Windows 7 operating system is recommended, and the code should run on either a 32-bit or 64-bit version. Administrator-level access is required for installation (due to the need for the Microsoft SQL Server database), but not necessarily for operation.

2.1.1 Hardware

SESSA operates on a desktop, laptop, or tablet PC. For on-scene use, laptops or tablets are strongly encouraged. The recommended minimum system configuration is:

- An Intel or comparable chip capable of running the Windows 7 operating system
- A reasonably large hard disk is recommended as the code and data can take up considerable storage.
- 2 GHz processor or faster
- 1 GB RAM or more
- Camera with at least 3 MP resolution
- Barcode reader
- Wi-Fi and Bluetooth connectivity
- At least one USB port
- For laptops and tablets, sufficient battery storage for several hours of run time
- Hardened case such that it is essentially dust proof and waterproof, capability of being decontaminated between crime scene or SSE deployments
- A screen that is easily visible in direct sunlight
- Touch screen capability is desirable

SESSA has been optimized to run on a Panasonic Toughbook H2 tablet computer. If a different computer is used, some functionality may not work, such as the camera.

2.1.2 Windows User Privileges

You must have Administrator user privileges to install SESSA on a computer. Administrator privileges allow the installation of such routines as the Microsoft SQL Server database.

2.2 Installing SESSA

To install SESSA on a desktop, laptop or tablet computer, the user will have to manually copy files from a portable thumb drive and execute some installation packages.

3. USING THE SESSA SOFTWARE

This section of the guide will step the user through the basics of using the SESSA software. The intent of this section is to make the user aware of the basic functionality of the code.

3.1. Getting Started

To get started, locate the SESSA.exe file or a shortcut and double-click on it to launch the application. The first screen should look like this:

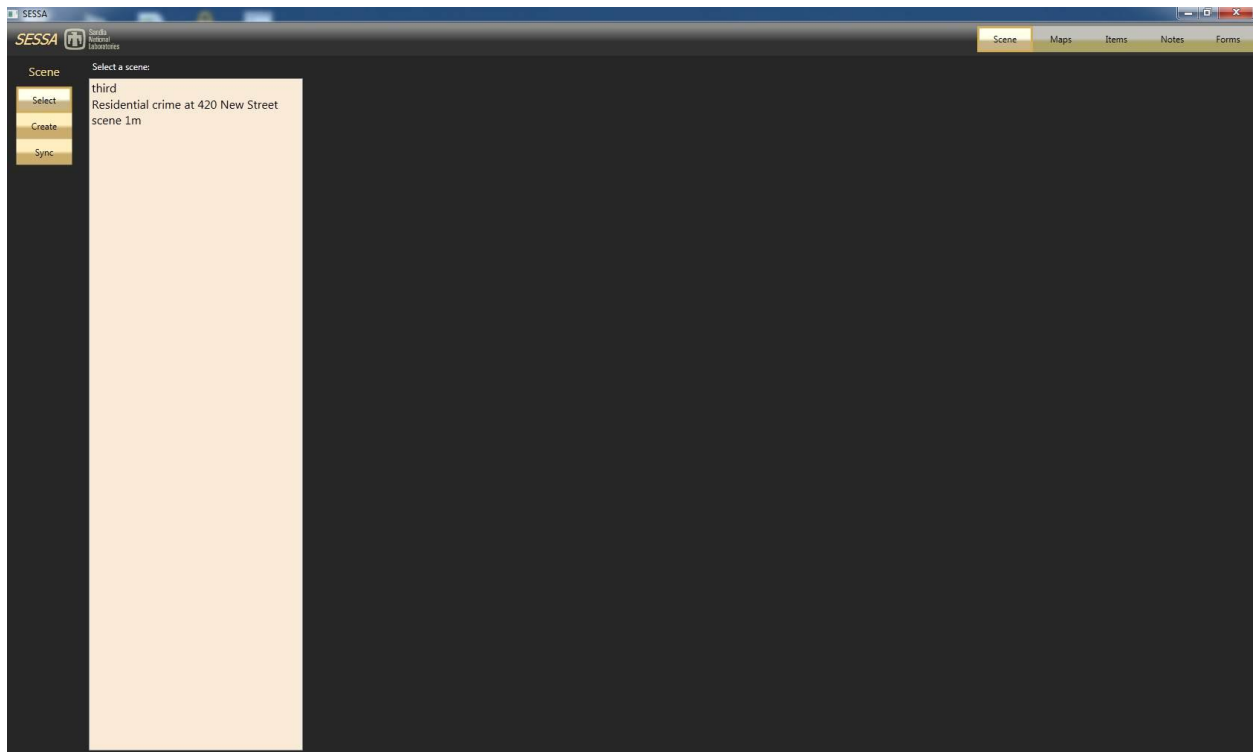


Figure 3-1. SESSA main screen

SESSA is designed with the Windows Presentation Foundation (WPF) system. There was a conscious decision to avoid clutter in the design of the Graphical User Interface. As shown in Figure 3-1, there are button options on the left and upper right portions of the screen. The buttons on the left will change depending on the selected mode of operation from the buttons on the upper right. The default condition when the SESSA software is first launched is to select a scene, either by creating a scene or selecting an existing scene. Data are aggregated and

integrated at the scene level. If scenes have already been created, a listing will appear in the pink rectangle. The user may select from the existing scenes shown in the list.

When beginning a new scene investigation, select the *Create* button on the left. Figure 3-2 shows the subsequent window for creating a scene.

Figure 3-2. Create a scene screen

The user is prompted to give a name for this particular scene. In addition there is a field for the user to supply a description regarding the scene. When done, select *Save*.

Once a scene has been created and/or selected, the user has several options. They can begin creating forms to document activities and people involved in the crime scene. Alternatively, they can start assembling the map products for the scene. The user is encouraged to follow the DoJ (2012) and USACIL (2013) evidence collection and preservation procedures.

3.2. Creating a Form

If the user chooses to create a form, Figure 3-3 shows the screen from which they can select from the currently available forms.

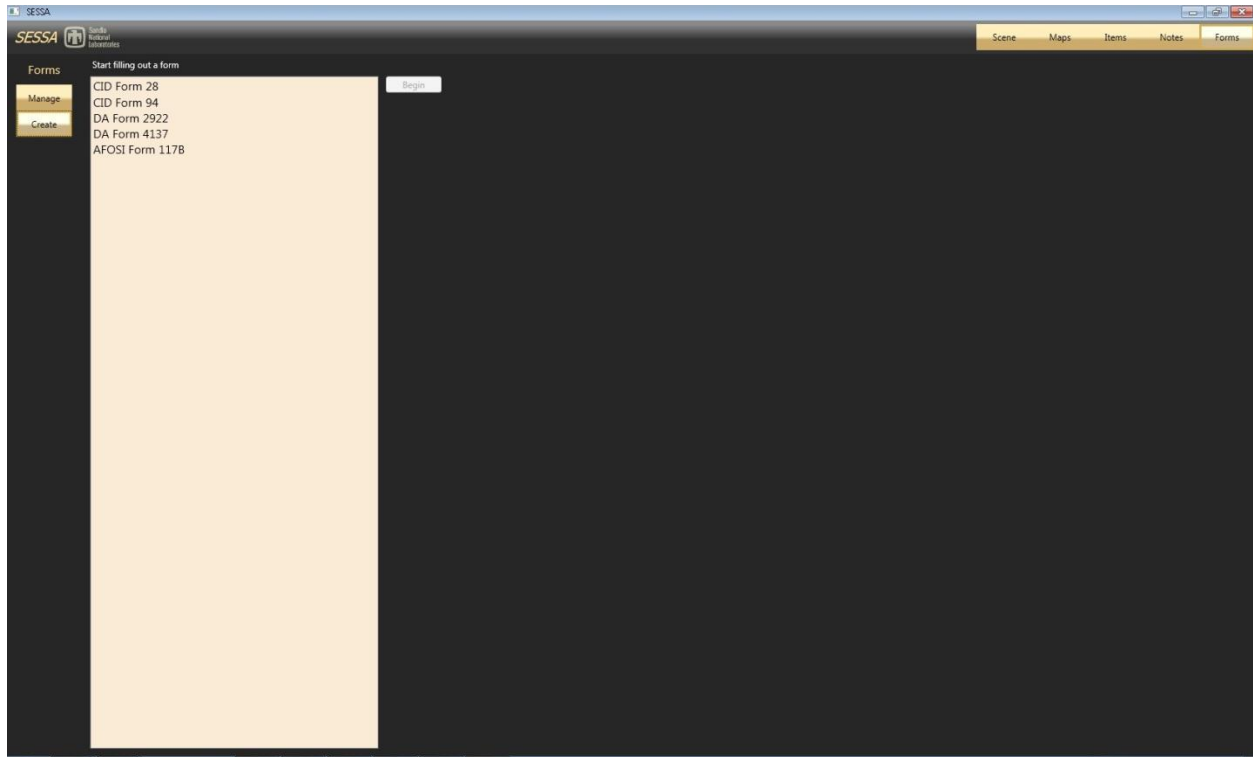


Figure 3-3. Form selection screen

Once the user has selected a form, select the *Begin* button. Figure 3-4 shows the screen used to input data for a CID Form 28, the Agent Activity Summary.

The screenshot shows the SESSA application window. The title bar says 'SESSA'. The menu bar includes 'Scene', 'Maps', 'Items', 'Notes', and 'Forms'. The left sidebar has a 'Forms' section with 'Manage' and 'Create' buttons. The main area is titled 'CID Form 28 - Agent Activity Summary'. It contains fields for 'Control Number' (537), 'Date' (4/25/2013), and 'Time' (9:35). Below these is a 'Summary of Investigative Activity' text area containing the text: 'Responded to the residence following a report of a breaking and entering, followed by assault and battery. Victim taken to hospital. Knife found on carpet in living room. Blood splatter in a different location in living room.' At the bottom right are buttons for 'Finalize', 'Save', 'Generate PDF', and 'Cancel'.

Figure 3-4. CID Form 28 input screen

The user has the option to save this form at any time and call it back up to edit or add to it. That is until they want to finalize the form. Once the user decides to finalize a form, it cannot be edited, it will be locked down. When the user selects finalize a pop-up window warns the user about this choice and forces them to select OK to continue the finalization process. Figure 3-5 shows this pop-up window.

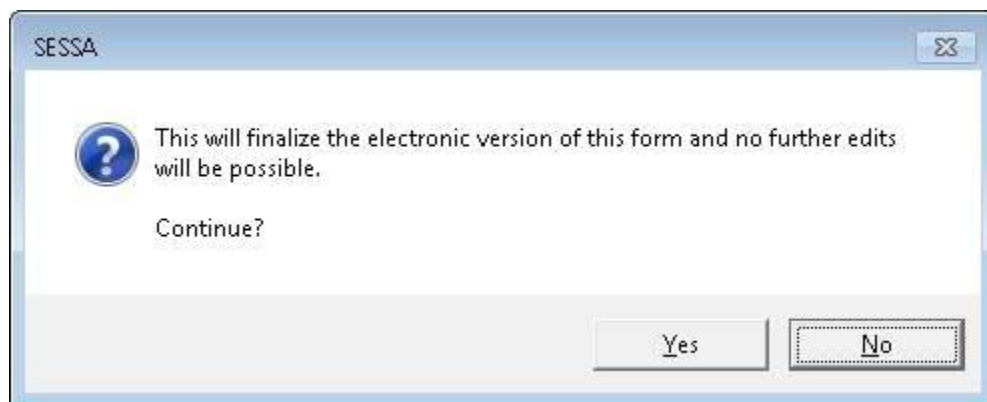


Figure 3-5. Finalizing a form pop-up window

If the user selects *Yes*, to finalize the form, a second pop-up window will appear to give the user the option to create the PDF version of the form, as shown in Figure 3-6.

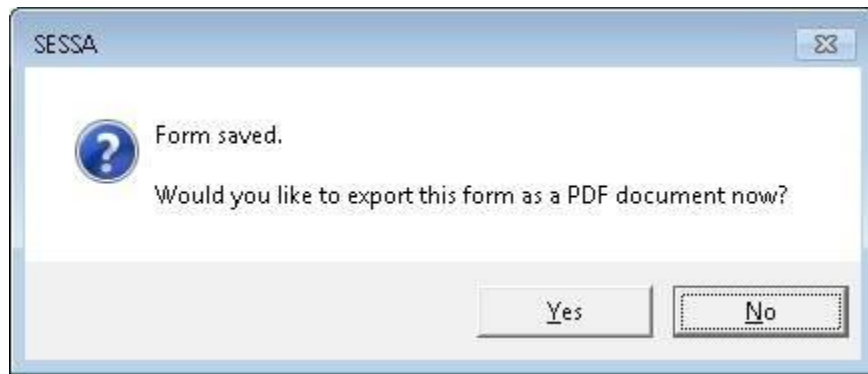


Figure 3-6. Finalizing a form to a PDF document pop-up window

The PDF version of a form places the text input by the user onto the official Government form. Figure 3-7 shows an example of a completed form.

AGENTS ACTIVITY SUMMARY (CID Regulation 195-1)		Control Number 537
TIME, DATE, AND AGENT 9:35, 25/4/2013, replaceWithAgentName	SUMMARY OF INVESTIGATIVE ACTIVITY Responded to the residence following a report of a breaking and entering, followed by assault and battery. Victim taken to hospital. Knife found on carpet in living room. Blood splatter in a different location in living room.	
<div style="display: flex; justify-content: space-between; align-items: flex-end; padding-top: 20px;"> <div> CID FORM 28 1 Oct 80 </div> <div> PREVIOUS EDITIONS OF THIS FORM WILL BE USED UNTIL EXHAUSTED </div> </div>		

Figure 3-7. Finalized PDF form

Some forms require a signature. The signature is captured electronically and embedded in the final form in the appropriate signature block.

3.3. Mapping Module

The mapping module allows the user to access road maps and satellite imagery from the Internet, to access road maps from a stand-alone, world-wide map suite, bitmap imagery (e.g., building layouts from ScenePD Pro), and products from the sketch pad module. When the user selects the *Maps* button the mapping module looks like the screen shown in Figure 3.8.

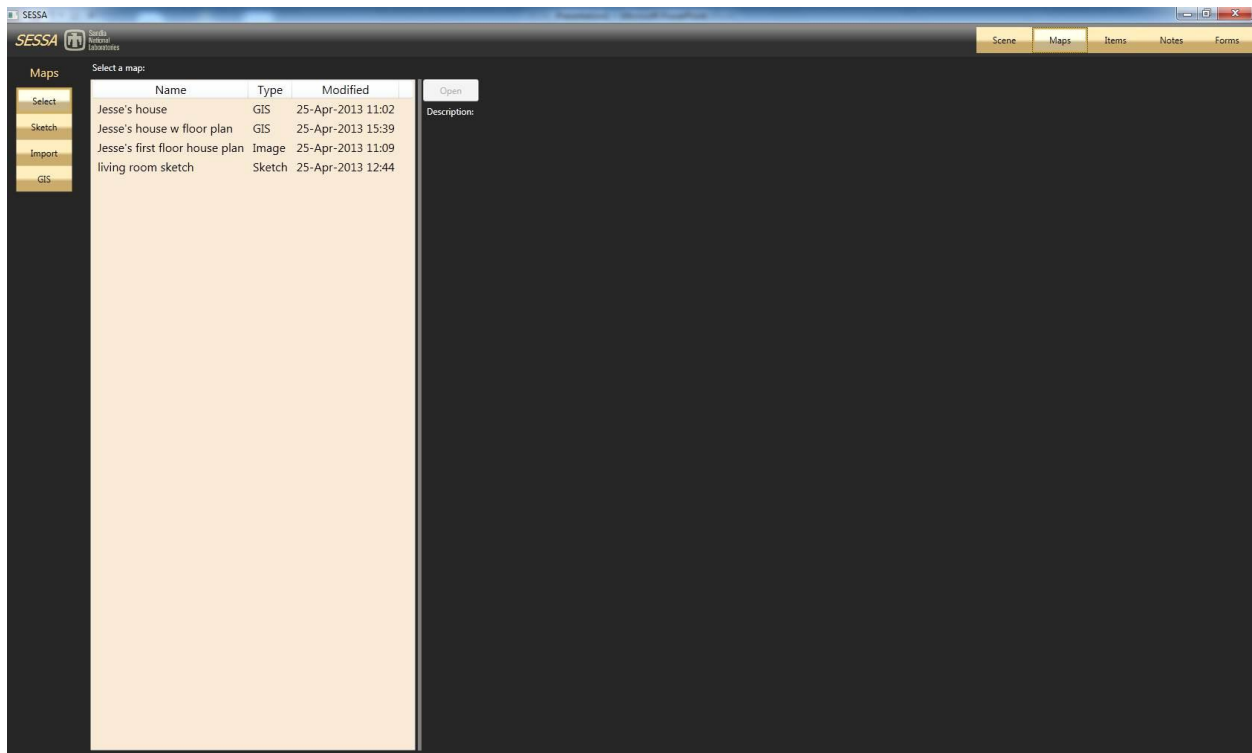


Figure 3-8. Main map screen

Now that the *Maps* module is selected, the buttons on the left side have changed. Button options now include *Select* (to select an existing map product from the list adjacent to the buttons), *Sketch* (to select the *Sketch Pad* module), *Import* (to bring in an existing bitmap image), and *GIS* (to view road or satellite maps).

Selecting the *GIS* button yields a spatial map, such as the one in Figure 3-9. This particular map is a satellite view provided by Google maps. To navigate or pan around the map the user places the stylus on the screen and moves it. To zoom in or out there is a control in the upper left corner of the map with a plus and minus sign on either end that controls the zoom level. The circular control above the zoom control may also be used to pan around the map.

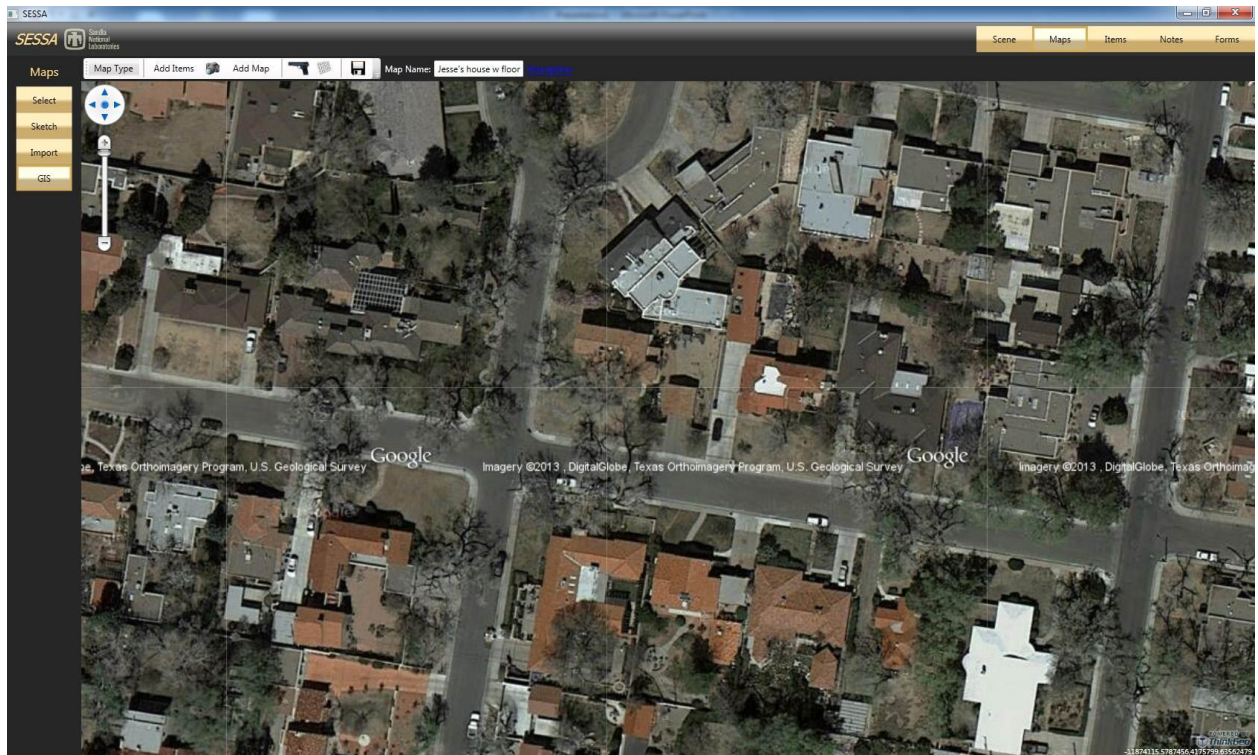


Figure 3-9. GIS map with *Google Satellite* view

At the top of the map are some controls. The first, on the left, is the *Map Type*. Selecting this button reveals a drop-down menu for map options, as shown in Figure 3-10. The options are: *Google Roads*, *Google Satellite*, *Google Hybrid*, *OpenStreetMap*, and *Disconnected Mode*.

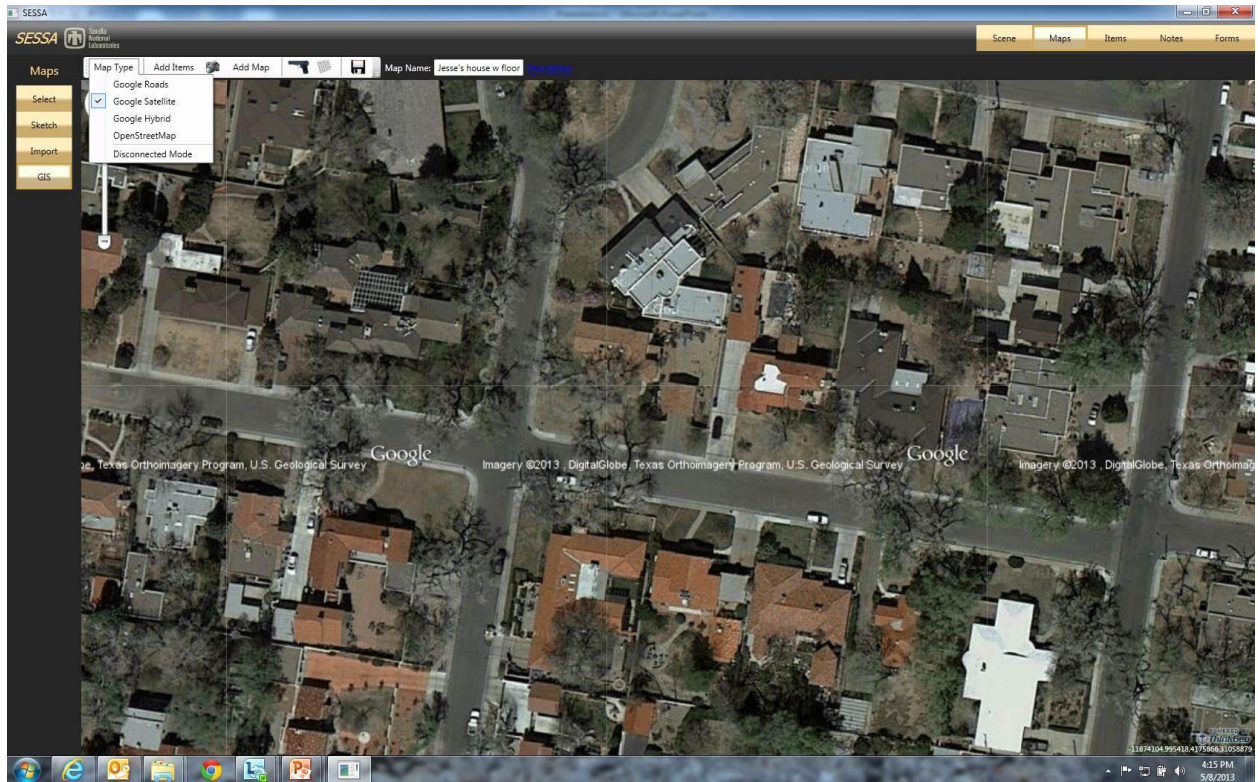


Figure 3-10. *Map Type* options drop-down menu

Figure 3-11 shows the Google Roads view.

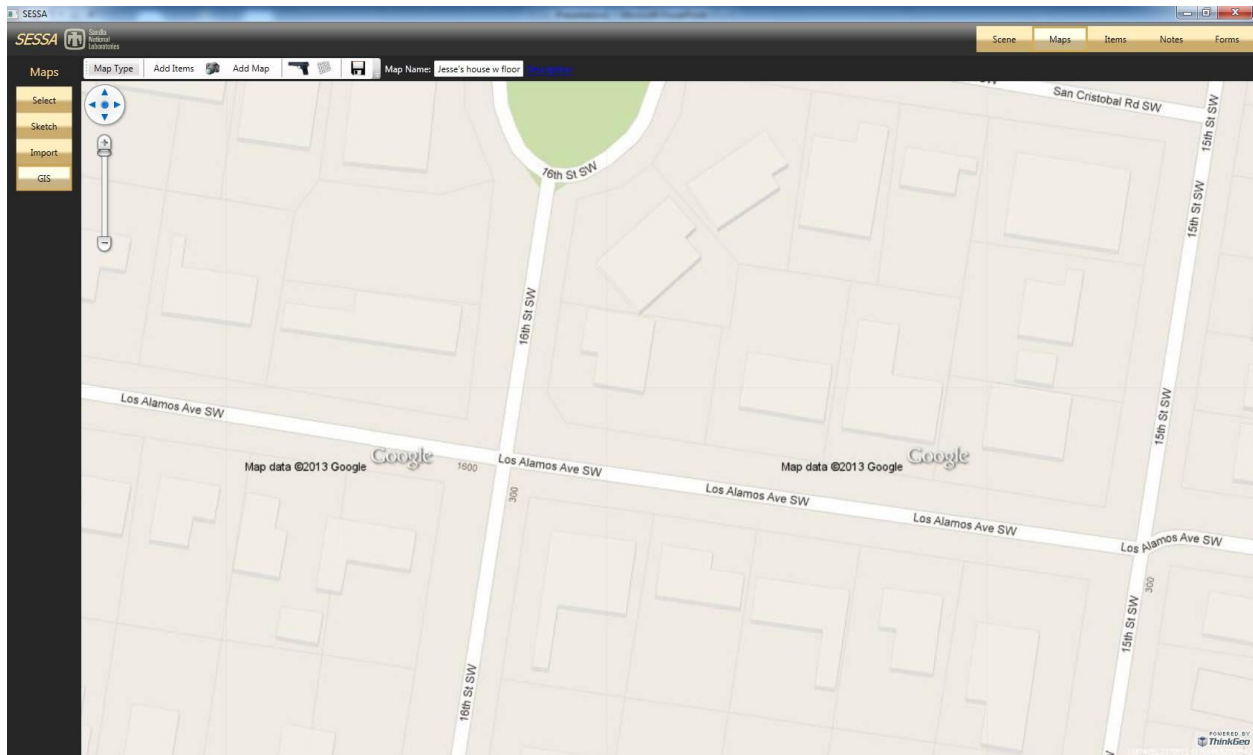


Figure 3-11. Google Roads map option

Figure 3-12 shows the OpenStreetMap view.

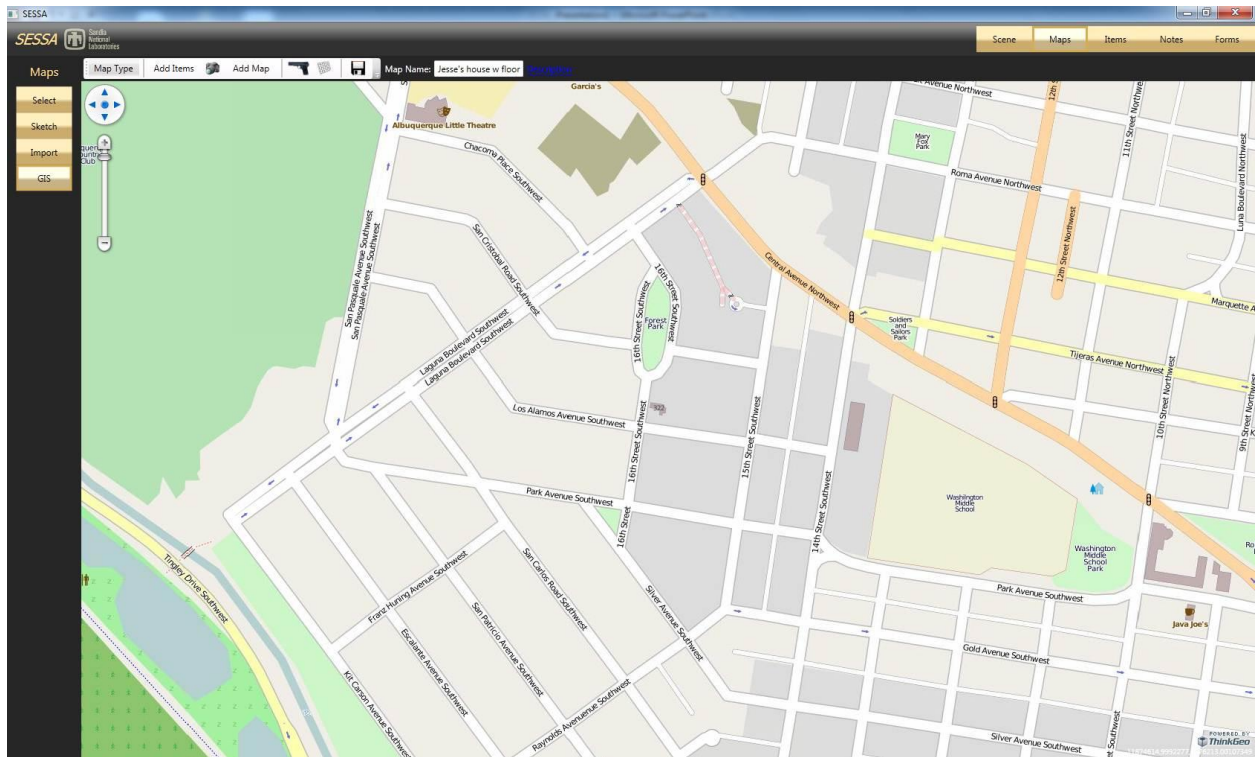


Figure 3-12. *OpenStreetMap* map option

Figure 3-13 shows the *Disconnected Mode* view.

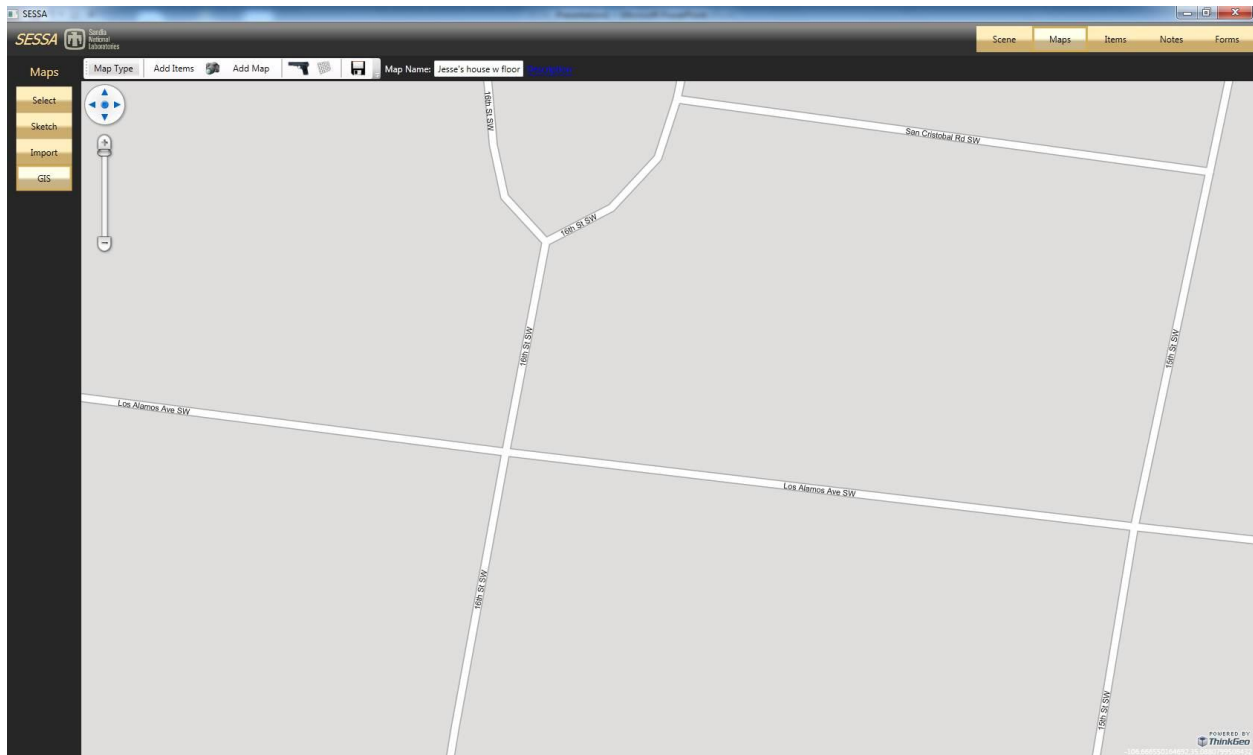


Figure 3-13. *Disconnected Mode* map option

The next control at the top of the GIS map window is *Add Items*. Items are basically evidence categories. When the user selects *Add Items* they would select a location on the map where they intend to place an evidence icon. Then a pop-up window appears with a list of available evidence icons to choose from. Figure 3-14 shows the pop-up window for evidence icon selection.

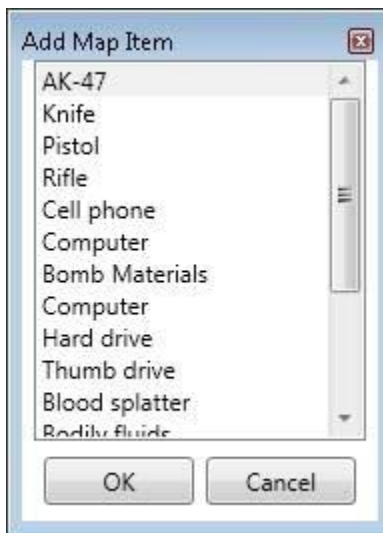


Figure 3-14. *Add Map Item* pop-up menu

The list of currently available evidence icons in the *Add Map Item* pop-up window includes:

- AK-47
- Knife
- Pistol
- Rifle
- Cell Phone
- Computer
- Bomb Materials
- Hard drive
- Thumb drive
- Blood splatter
- Bodily fluids
- Body
- Body parts
- Finger prints
- Drug paraphernalia
- Photo

Once an evidence icon is placed on the map, the user has the ability to associate notes with that icon and forms. More on that later in this chapter.

The next button at the top of the mapping window is *Add Map*. The *Add Map* button allows the user to place a bitmap on top of the satellite or road map. The main purpose of this option is to put building layout maps onto the GIS layer in order to place evidence icons within a building, as appropriate. When the user selects *Add Map*, they are expected to drag a rectangle onto the map with the stylus that is approximately the same height and width ratio as the bitmap they are importing. Once the dragging procedure is done, a pop-up window will appear that prompts the user to select a bitmap image. Once the bitmap image is selected, SESSA places the bitmap onto the GIS map in the area that was scribed. An example of this embedded bitmap on the GIS map is shown in Figure 3-15.

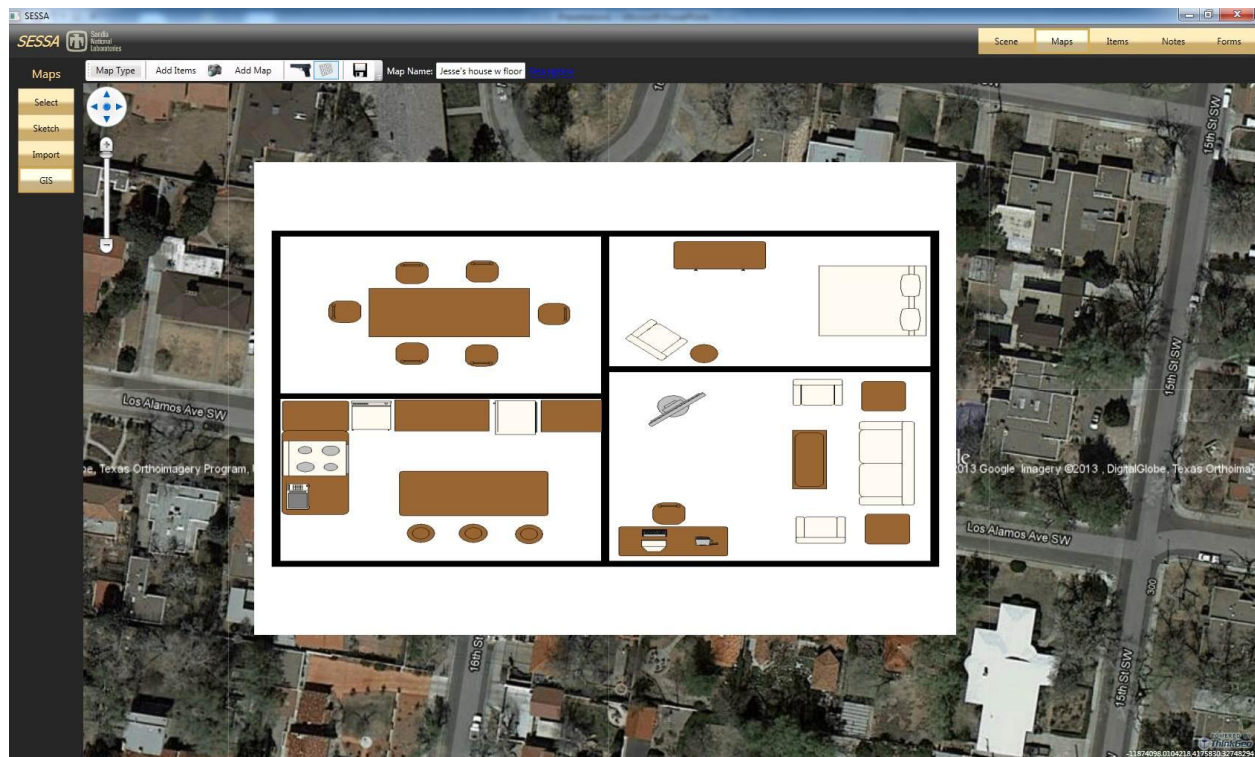


Figure 3-15. Bitmap placed on the GIS map

Going back to the Add Items functionality, if an evidence icon is placed on the map it will look something like the ones shown in Figure 3-16, which shows a knife and a blood splatter icon.

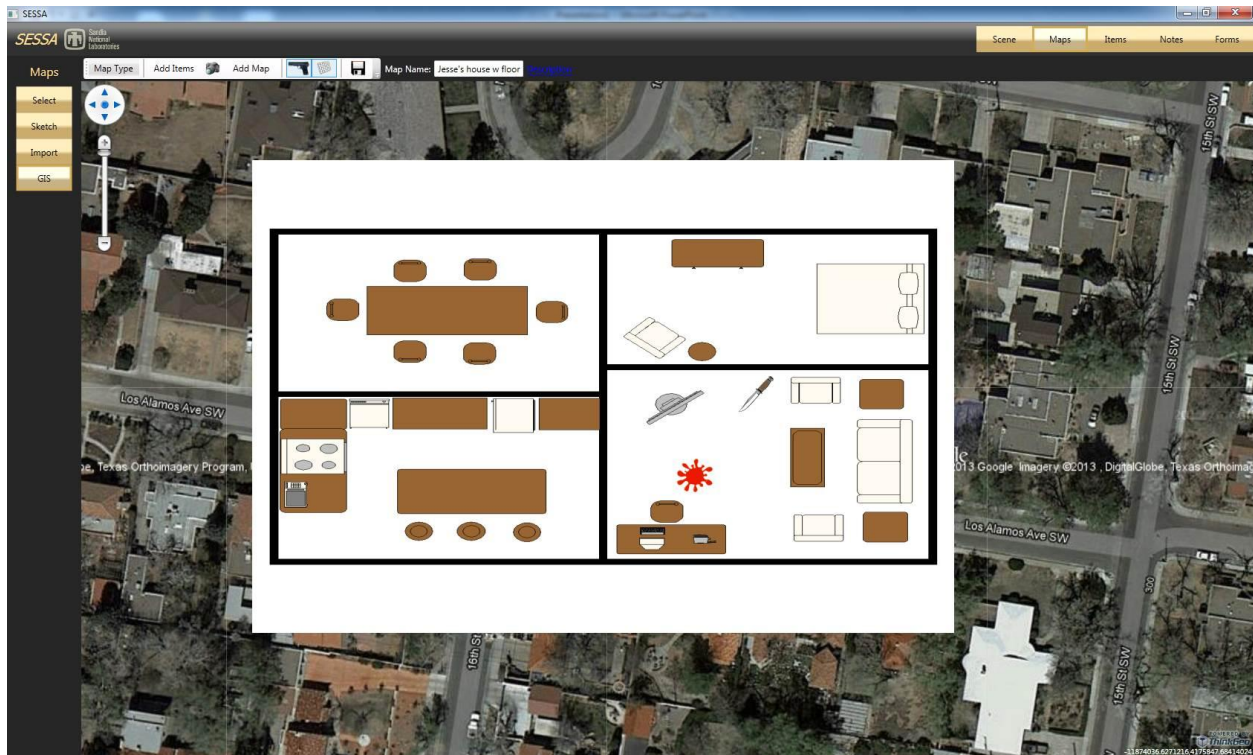


Figure 3-16. Evidence icons placed on the map

To add a form or a note to any evidence icon, the user holds down the stylus on the icon. Alternatively, if using a mouse to navigate, it is a right mouse click. A pop-up menu occurs, as shown in Figure 3-17.

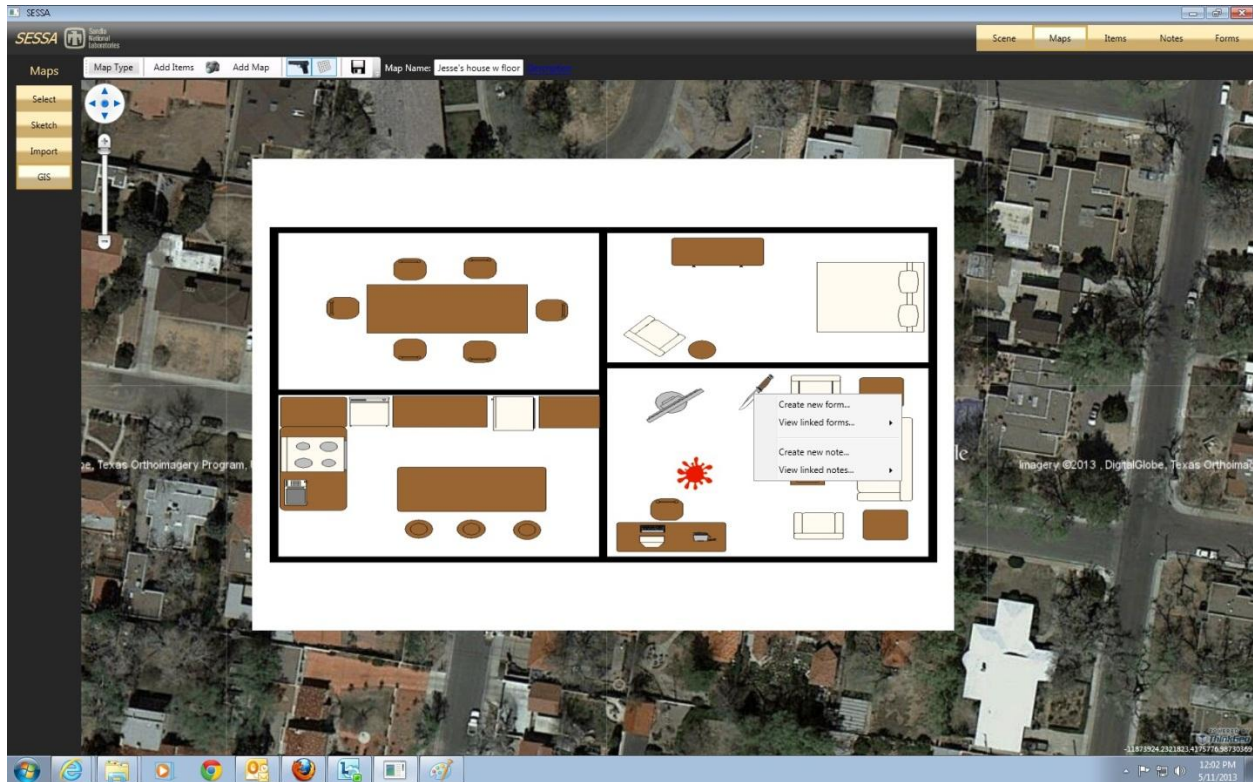


Figure 3-17. Pop-up menu for evidence icon

This menu allows the user to select: *Create new form*, *Select linked forms*, *Create new note*, or *View linked notes*.

Continuing with the button options at the top left of the GIS map window, the button with the gun icon will toggle the evidence icons from view on the map. The next button to the right, which looks like a mesh, will toggle the bitmap imagery from view on the GIS map window. Next over, the disk icon allows the user to save the imagery. To the right of the buttons is a dialog box that allows the user to specify a *Map Name* for this particular map view. To the right of the name is a *Description* button which allows the user to describe this map view.

The *Sketch* button on the left of the map window will launch the Sketch Pad module. Figure 3-18 shows the sketch pad module with a hand-drawn sketch in the mapping window.

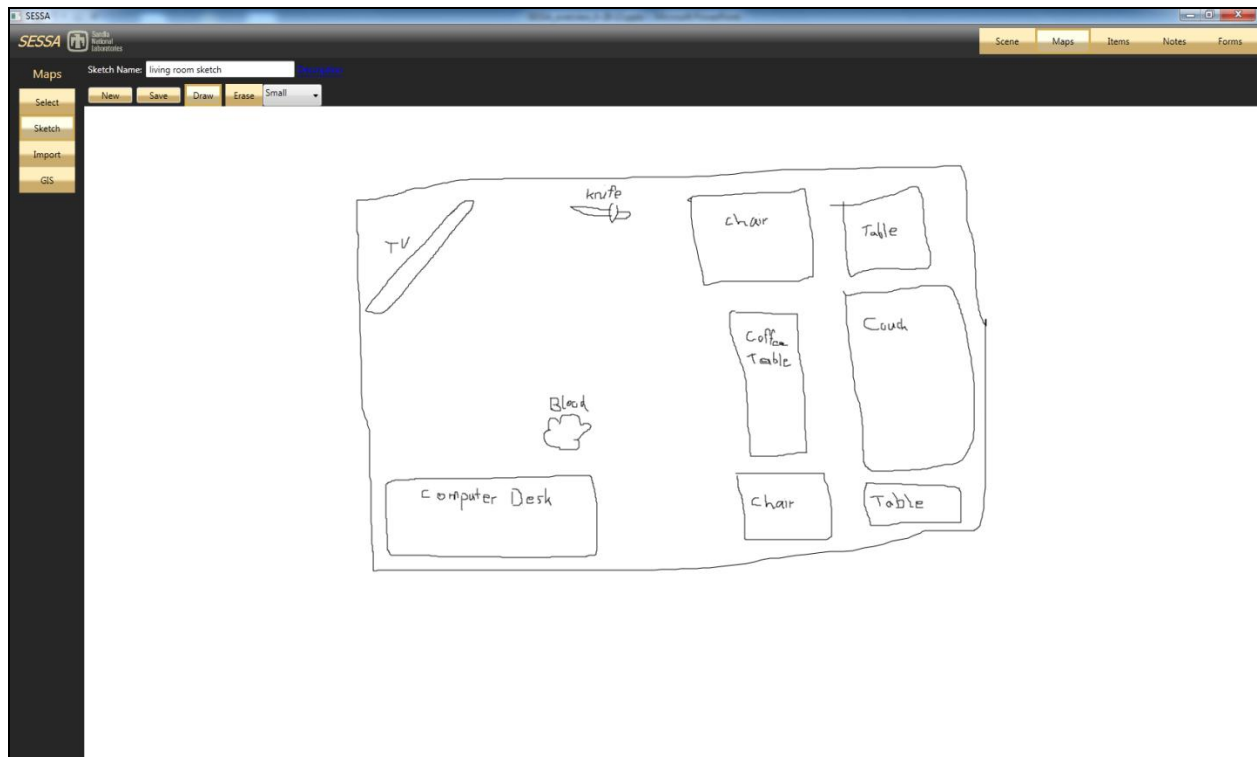


Figure 3-18. Sketch Pad module at startup

Within the Sketch Pad module, there are controls at the top left. There are buttons for starting a *New* sketch and to *Save* a sketch. There is a button to *Draw*, which allows the user to sketch in the pad area of the window with the stylus. There is also an *Erase* button, to delete portions of the sketch much like erasing on a white board. There is a drop-down menu that allows the user to select the size of the sketch lines, with the choices being small, medium and large widths. Above the button controls there is a dialog input for a *Sketch Name* and an optional *Description* field.

The next button of interest in the *Maps* module is the *Import* button on the left side of the window. The *Import* feature allows the user to select a bitmap image and add it to the selection list of available maps. After selecting the Import button, the user will see a standard pop-up window for selecting a file.

3.4. Items Module

When evidence items have been placed on the map the user creates notes and forms associated with that evidence. The *Items* module allows the user to view and edit the various data associated with the listed items. Figure 3-19 shows the *Items* window.

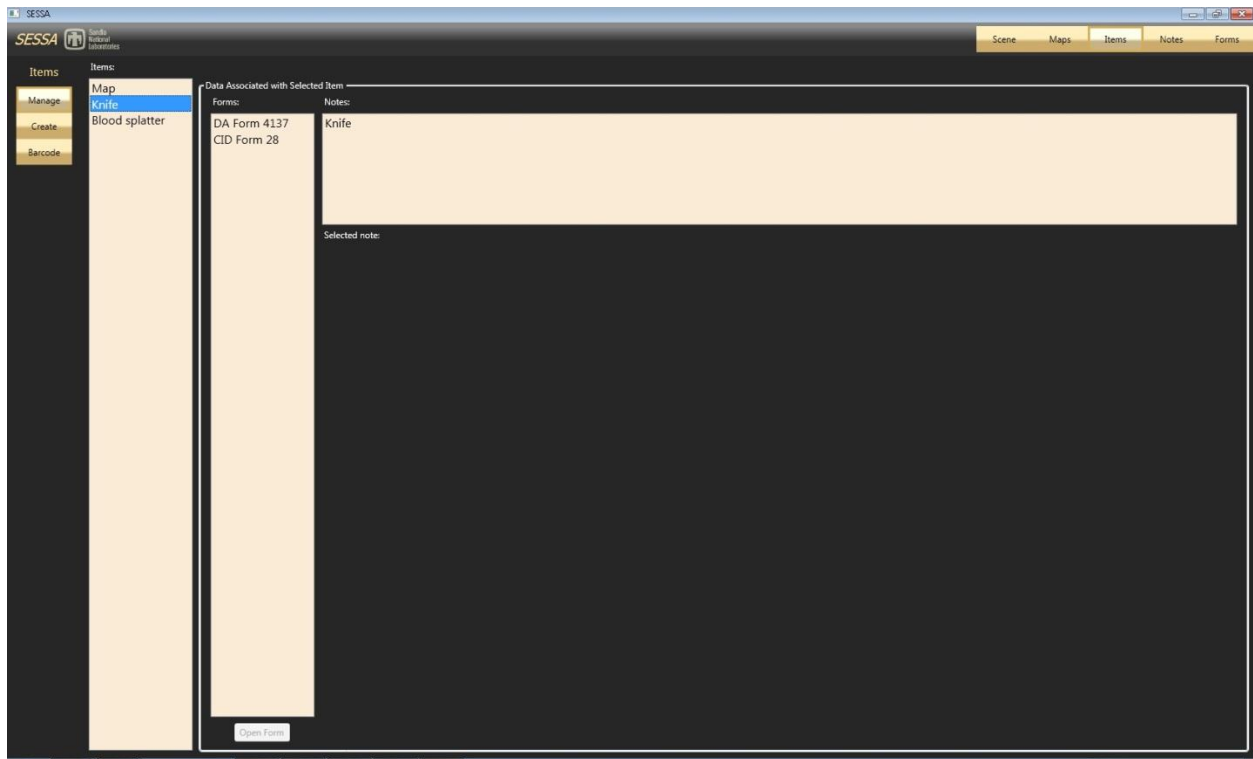


Figure 3-19. Items screen

From this window each evidence icon in the left hand list may be selected. If any forms or notes have been logged for that particular piece of evidence it is shown in the two lists to the right of the Items list. The user can select and view any of these forms and notes.

Another feature in the SESSA toolkit is the ability to both generate and read barcodes. The button in the *Items* window on the left called *Barcode*, when selected brings up the window shown in Figure 3-20.

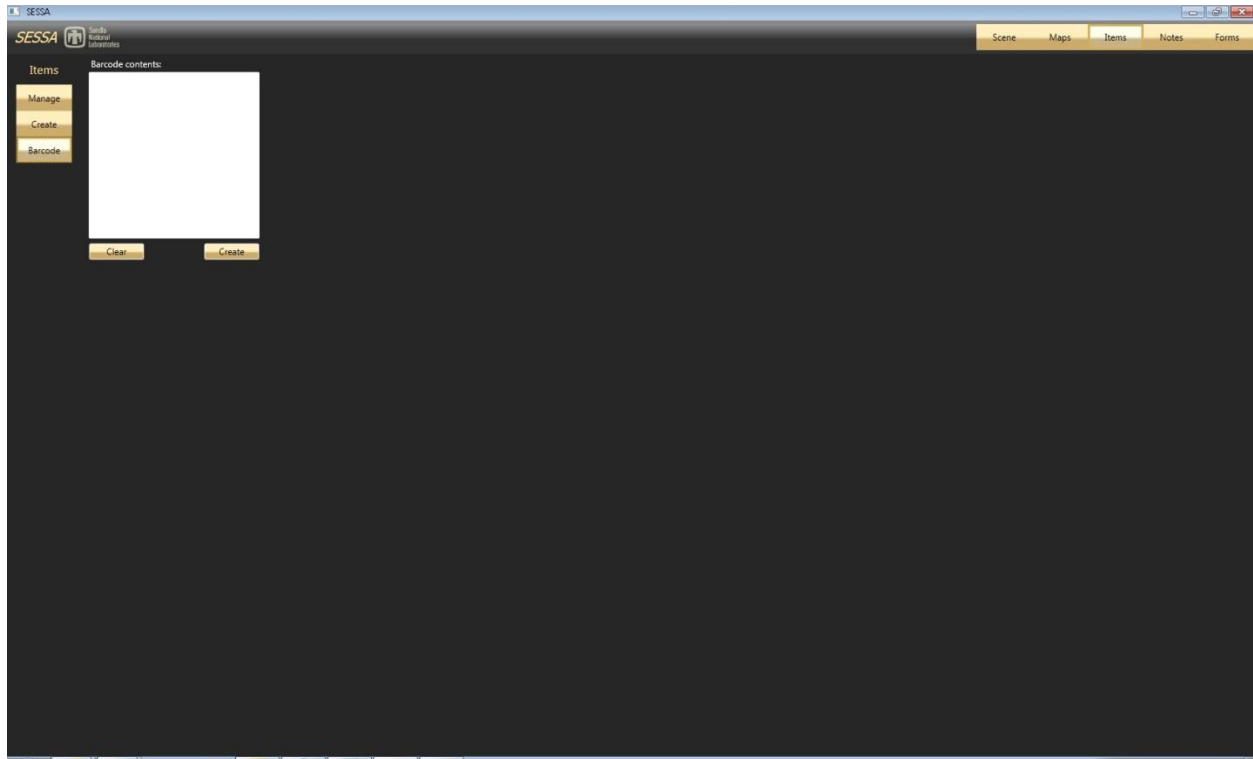


Figure 3-20. Barcode screen

The user types in the barcode ID they want to generate into the text box of the *Barcode* window. Once the text is complete, the user selects the *Create* button. A barcode is generated on the screen, such as that shown in Figure 3-21.

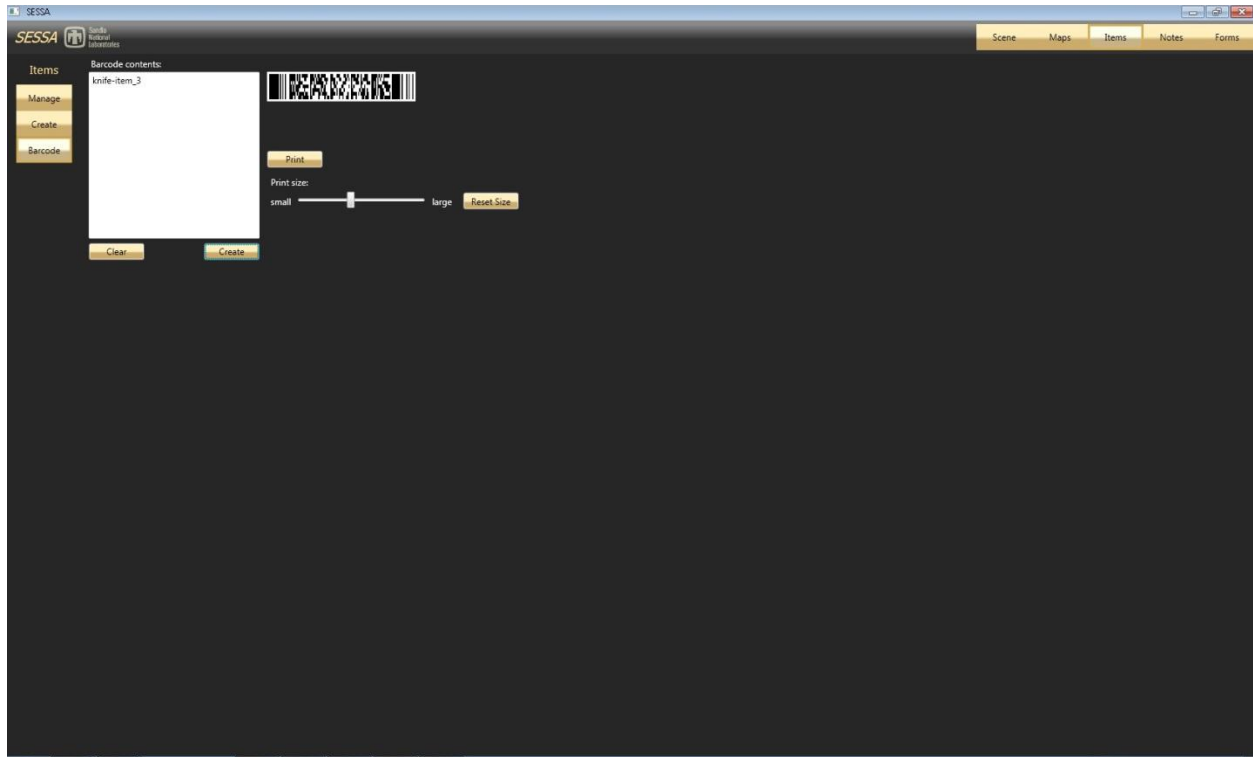


Figure 3-21. Barcode generated on the screen

The user now has the ability to size the barcode for printing with the slider bar shown in Figure 3-21. There is also a *Print* option. In this manner the Barcode can be printed to a stick-on printed label if desired.

3.5. Notes Module

When the user selects the *Notes* button in the upper right of the window, the screen shown in Figure 3-22 will appear. If notes have already been created from placing evidence icons in the *Map* module they will be listed in this window. Selecting a note displays its contents.

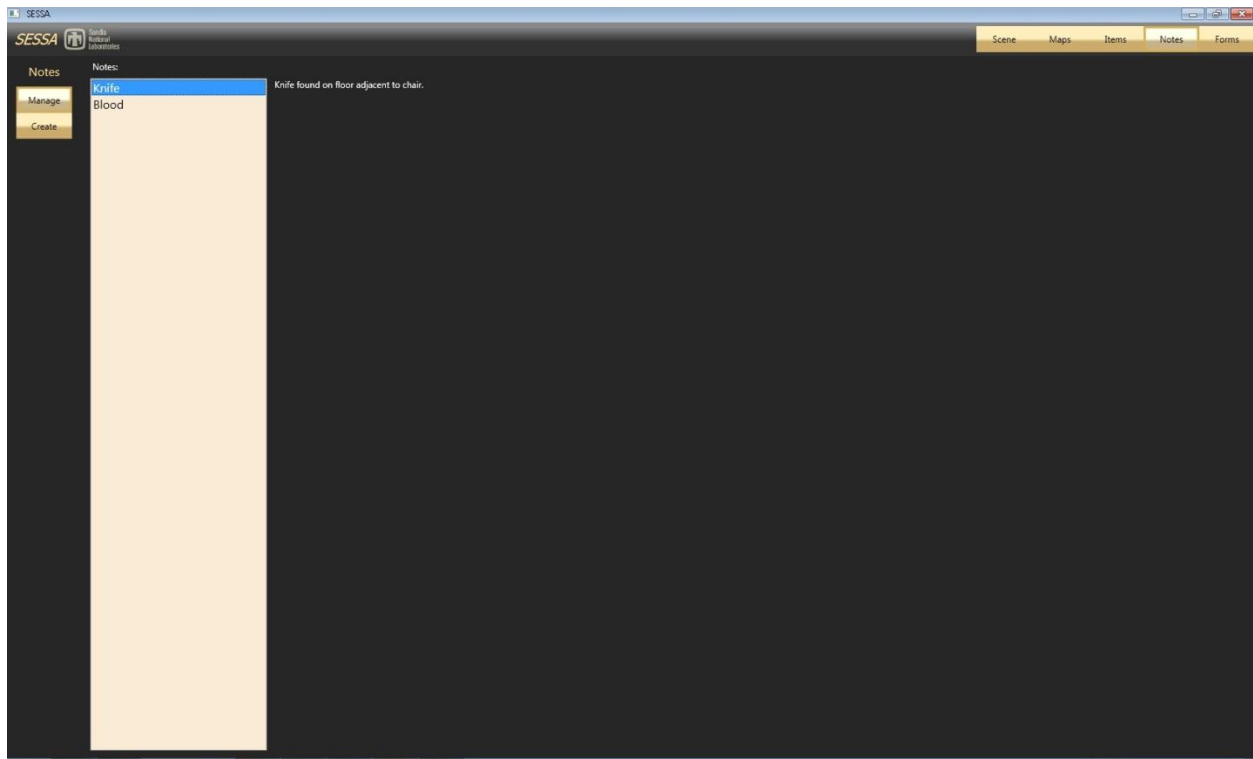


Figure 3-22. Notes window

If the user wants to create a new note from the Notes window, just select the Create button on the left. This yields a new window that looks like Figure 3-23. The note can be given a title and some text.

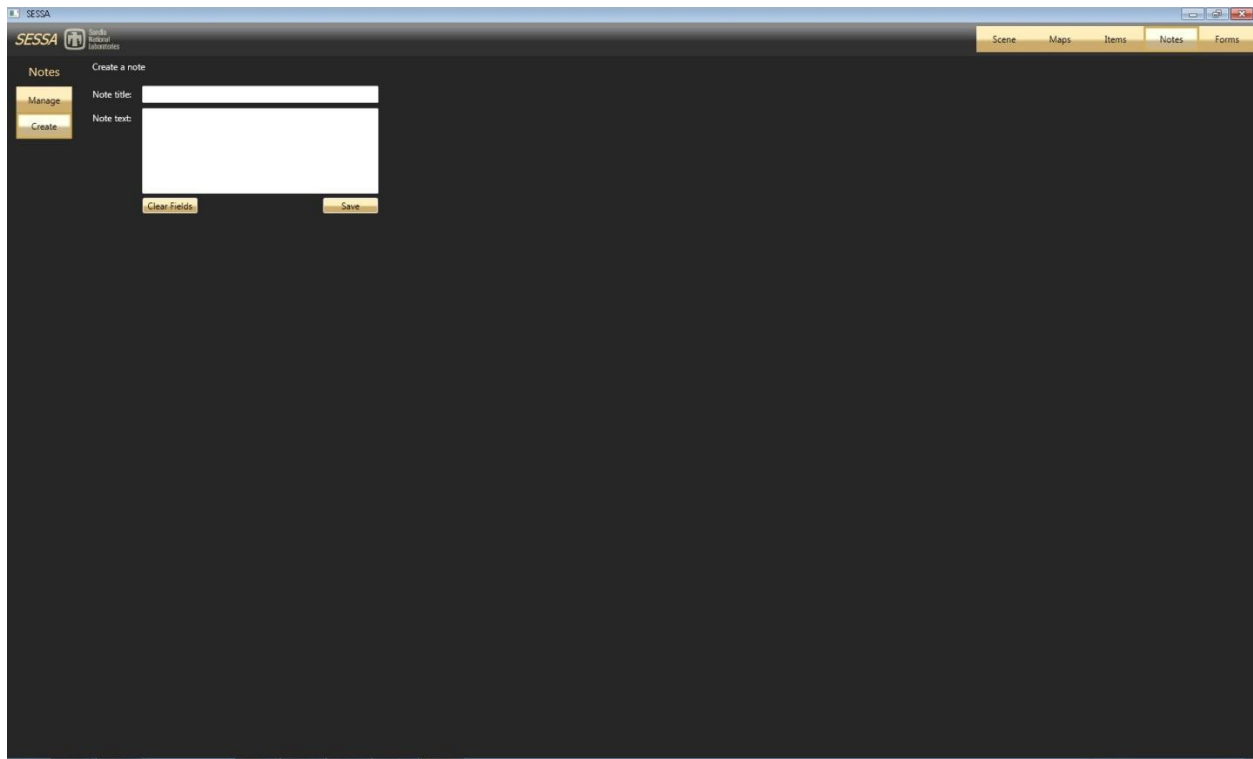


Figure 3-23. Create a new note screen

3.6. Synchronizing Work by Multiple Agents

It is possible to synchronize the work performed by multiple agents during an investigation. It is recommended that any base maps that will be used by the various agents be generated by one agent, preferably the lead agent in charge, and distributed to the other agents to make the synchronization possible relative to spatial placement of evidence. In the main Scene window there is a button on the left side that reads *Sync*, as shown in Figure 3-24.

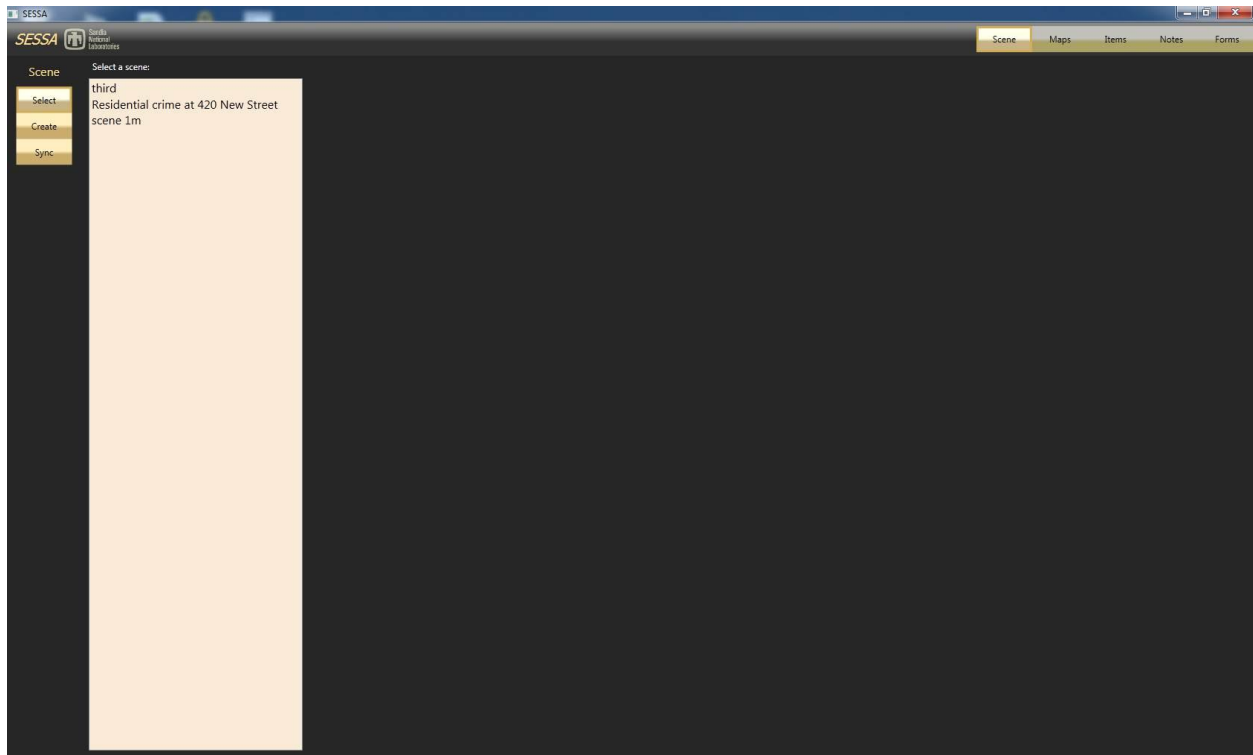


Figure 3-24. Sync button on Main *Scene* window

When the user selects the Sync button a new screen appears, as shown in Figure 3-25.

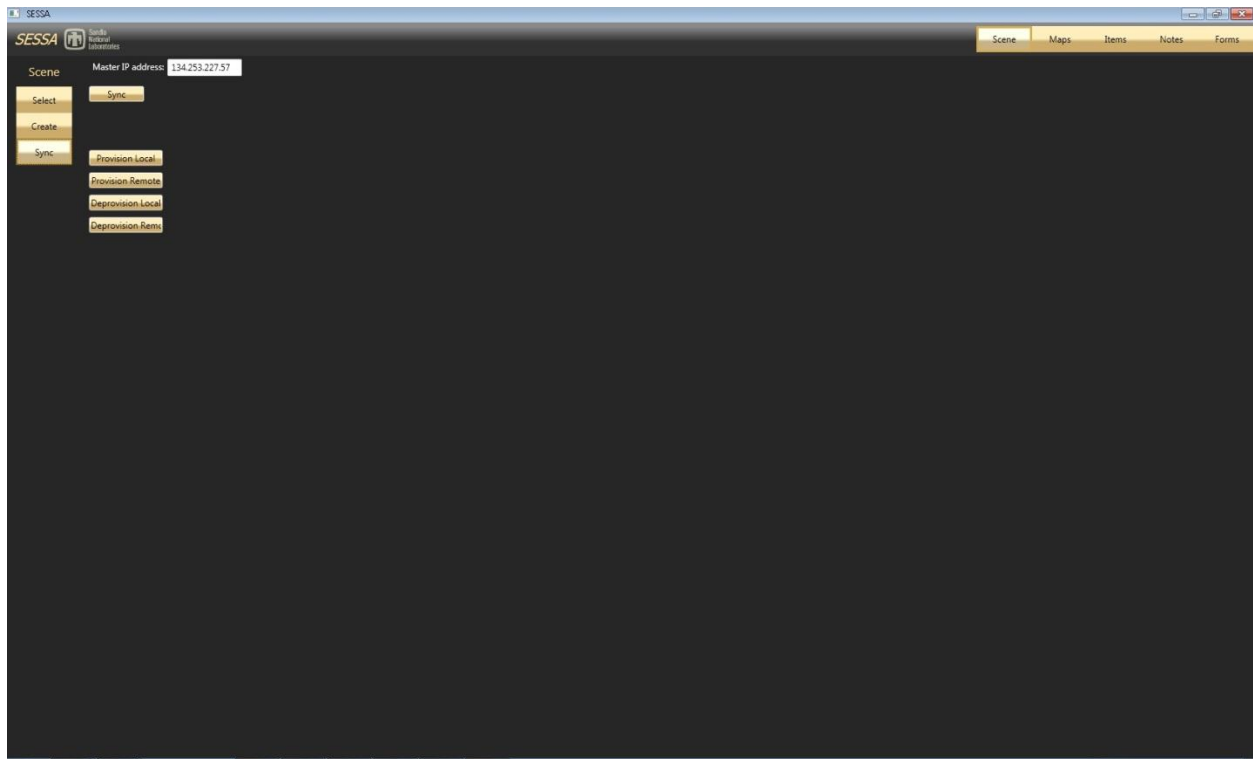


Figure 3-25. Sync screen

The users will need to be able to wirelessly communicate between their respective Toughbook tablet computers in order to perform the synchronization. A wireless router can set up an ad hoc network that the tablets can communicate over. A Master IP address is needed for the router and is input to the dialog box shown in Figure 3-25. (More to come on this topic)

3.7. 3D Model Builder System

As mentioned above, a prototype 3D Model Builder mapping system has been developed to complement the SESSA software. The intent of the 3D Model Builder system is to produce virtual 3D walk-throughs of a crime scene in essentially real time, with easy to use controls, and have the ability to allow the user to measure distances with centimeter accuracy. In addition, the cost needs to be reasonable. The prototype 3D Model Builder system has the potential to meet these needs.

SNL has developed a unique take on 3D mapping. At the heart of the system is an ASUS visual/depth sensor (http://www.asus.com/Multimedia/Xtion_PRO_LIVE/). The ASUS sensor sells for about \$150. This sensor captures a 640 x 480 grid of both visual information (red-green-blue light bands) and an infrared feed that provides depth information. The resolution is such that one can expect centimeter level accuracy in the 3D mapping representations produced by the system. Because the depth measurements are obtained from an infrared sensor, the accuracy falls off significantly past about 4 meters distance. In order to produce a 3D map of an interior space, some systems using the ASUS sensor operate it in a video capture mode and process a huge data set in order to map the space. The algorithms employed in these video

capture systems rely on a high-end Graphics Processing Unit (GPU) in order to perform the calculations in a timely manner. One of the unique aspects of the SNL system is that it does still frame, or snapshot, data capture with overlapping coverage between frames, thereby stitching together a 3D map with far less data than the video capture methods. As a consequence there is no need for a GPU to process the data. This is a good thing, given that the Toughbook tablet computer does not have a GPU. So the SNL system can function with the Toughbook and not require a separate system to develop 3D maps of a crime scene.

The operation of the 3D Model Builder system is best done with a custom bracket that houses the ASUS sensor, a cradle for the Toughbook, and a mounting plate that attaches to a quality tripod, such as a Manfrotto with a model 410 bracket. The model 410 bracket allows the user to level the tripod and increment the x, y, z rotation in known increments. Because the Toughbook only has one USB port, a USB hub is needed. In addition to plugging the ASUS into the Toughbook, it is recommended that an Xbox gaming controller be used to control the 3D Model Builder system. The 3D Model Builder software is implemented in a Unity gaming engine for ease of use in representing and navigating a 3D space.

Figure 3-26 shows a front-on view of the Toughbook and the custom bracket mounted to a Manfrotto tripod.



Figure 3-26. The Toughbook setup for implementing the 3D Model Builder system

Figure 3-27 shows a view of the backside of the setup, showing the ASUS sensor mounted to the bracket.



Figure 3-27. The ASUS sensor attached to the custom bracket

Once the system has been assembled and brought to a crime scene the tripod should be centered in the room if possible, unless it is a big room, in which case it may need to be done in increments. Next, the user should orient the tripod so that a 0° point on the tripod corresponds to the initial view desired for constructing the 3D map of the room. The tripod is then leveled. The height of the tripod needs to be measured to the base of the 410 bracket, in meters. This measurement is needed within the software to process the 3D imagery accurately.

The 3D Model Builder software is then launched on the Toughbook with the stylus. The first screen that appears is a setup window, as shown in Figure 3-28.

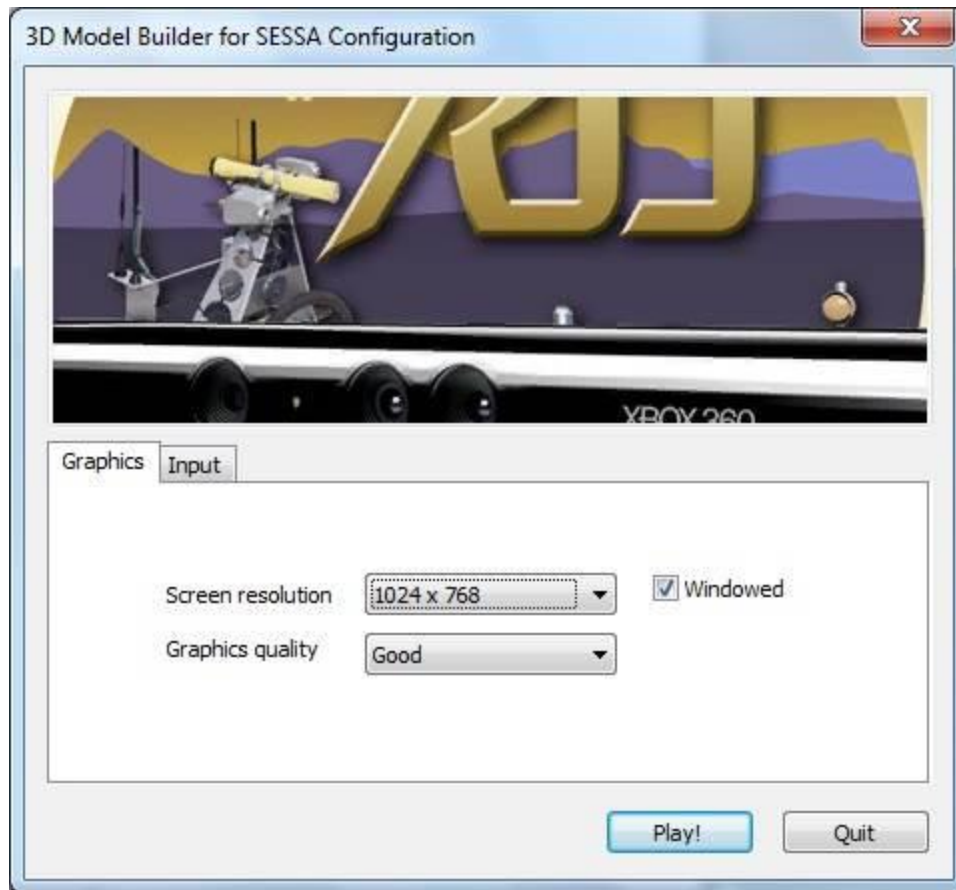


Figure 3-28. 3D Model Builder setup window

If using the Toughbook tablet computer, the default parameters in the setup window will be appropriate, so the user should select *Play!*.

Figure 3-29 shows an initial screen with the ASUS sensor supplying the video feed.



Figure 3-29. 3D Model Builder initial view

The buttons at the top of the 3D Model Builder software are for the following functions. The first icon representing a folder allows the user to manage 3D model products, to open scenes, save scenes, or delete scenes. The next icon toggles the live camera view on and off. The camera icon snaps a still-frame picture with the sensor. The icon with an arrow is a select function, which allows the user to select individual still-frame images collected during a 3D model build. The next icon is used to set up the orientation of the sensor for pan and tilt. The next icon allows the user to translate the imagery in the x, y, z as an off-set from the starting point. The icon with a tape measure allows the user to perform measurements within a scene. The icon with a red X in a circle deletes the last still-frame photo taken. The next icon is Restore View.

Figure 3-30 shows the window when the File icon is chosen.

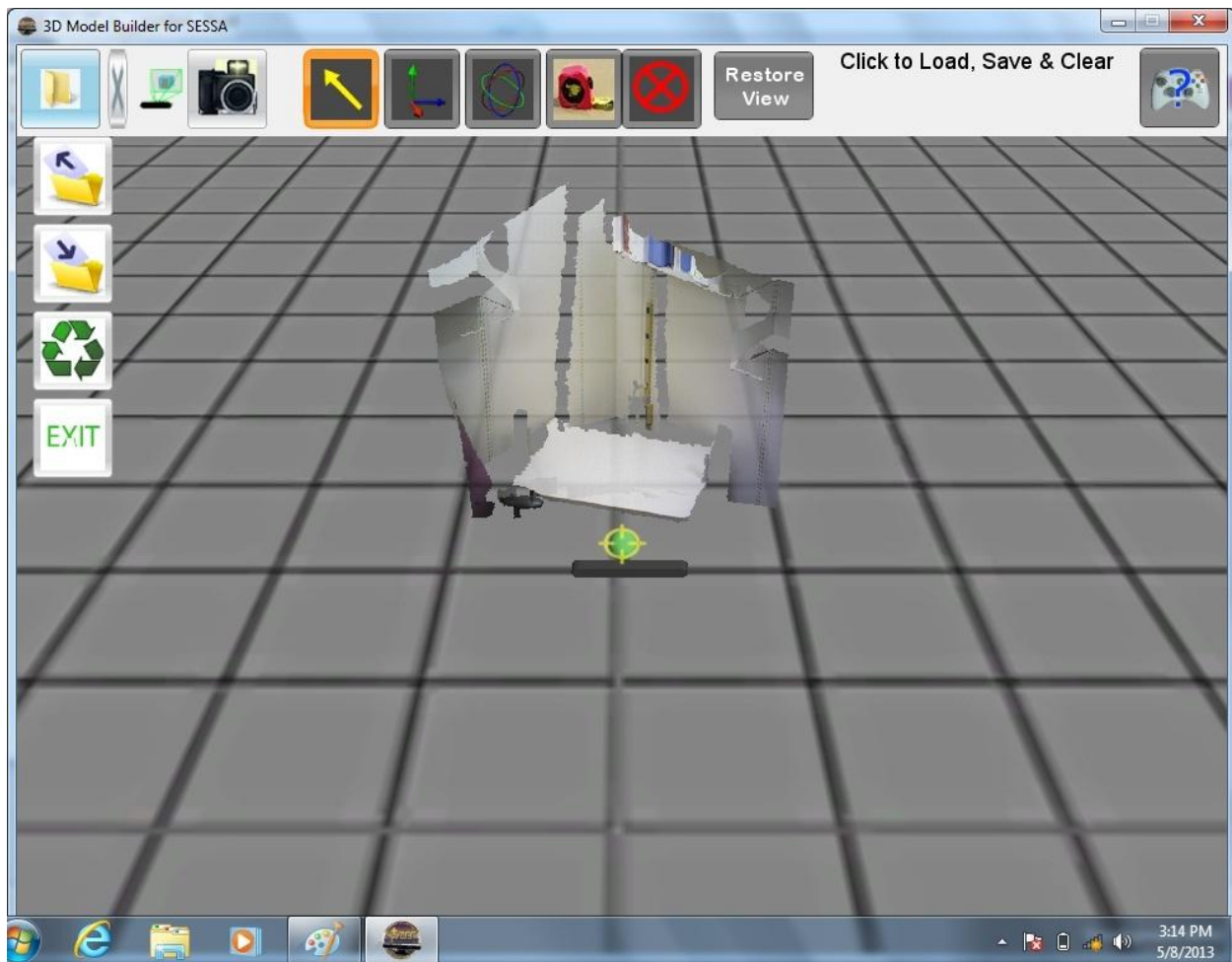


Figure 3-30. The File window for the 3D Model Builder

Figure 3-31 shows the alignment of the camera view on the scene when the live camera view is toggled.

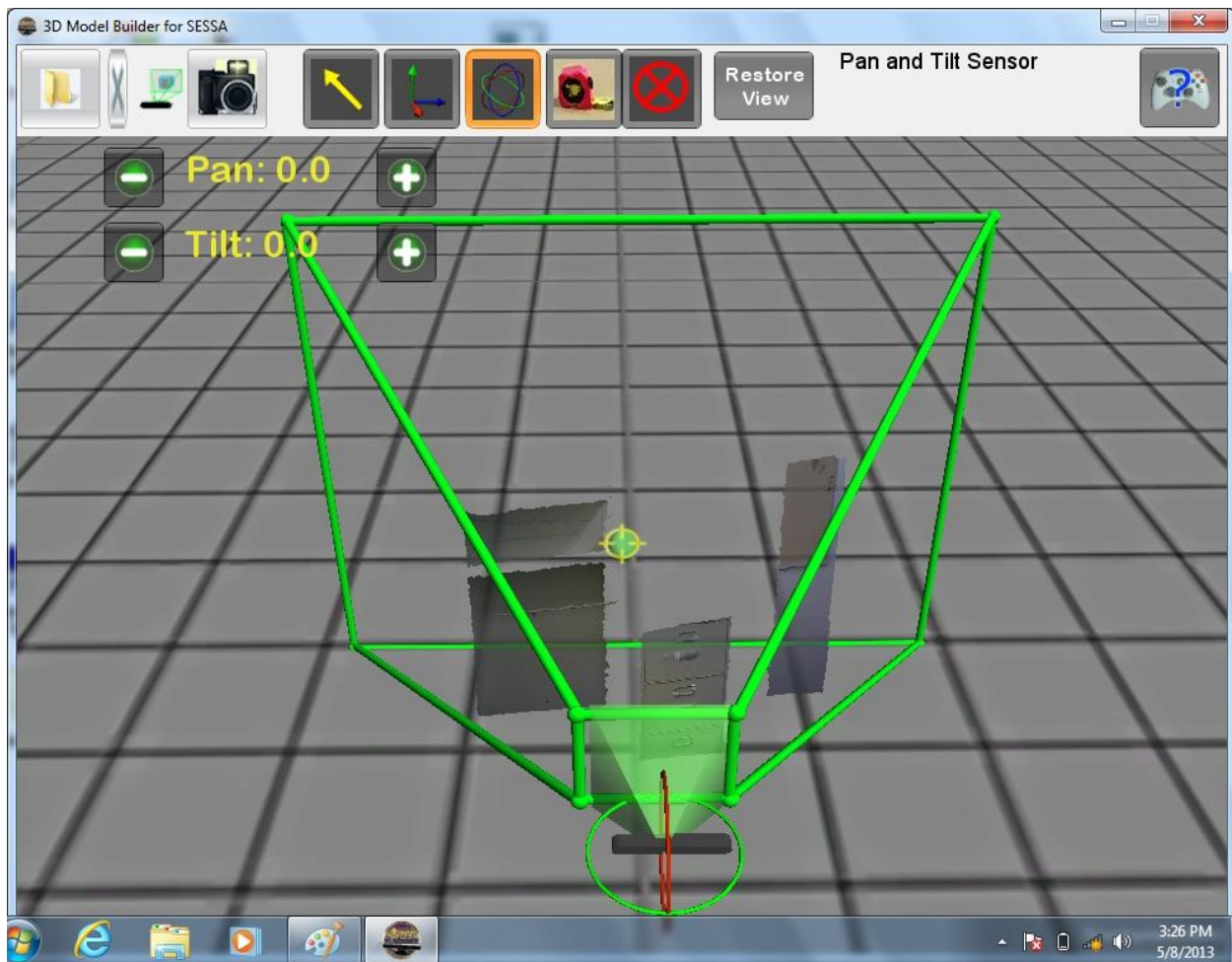


Figure 3-31. Live View frame for camera feed

When the pan and tilt icon is selected the screen looks like that shown in Figure 3-31.

As mentioned, the best way to control the 3D Model Builder software when creating a 3D representation of a crime scene is with an Xbox controller. Figure 3-32 shows a picture of an Xbox controller and the functions of the buttons and controls on the device.



Figure 3-32. Xbox controller functions for the 3D Model Builder system

It takes a bit of practice, but using the joy-stick controls and other buttons on the controller to move around a 3D scene is quite efficient. The colored buttons allow for several other functions. The yellow button takes a still-frame snapshot. The blue button sets one of the locations for measuring a distance in a 3D scene. The red button provides the second set point for the distance measurement. The green button is used to select an object. This graphic is accessible in the 3D Modeler software with the icon in the upper right corner of the software.

The concept of creating a 3D map of a crime scene is fairly simple. Once the tripod is setup, the user takes a still-frame snapshot straight on with a 0° pan and 0° tilt. When the snapshot is taken the Toughbook will emit a sound like a camera shutter. The user needs to wait until a tone emits from the Toughbook signifying that the snapshot was taken and processed. Next the user systematically rotates the tripod in 45° increments, each time incrementing the pan value as shown in the pan and tilt window of Figure 3-31. Once back to the 0° mark, the unit is tilted 45° downward. The software is also incremented to reflect the change. The user then pans around again in 45° increments to capture the whole room again at this downward angle. Once back at the 0° mark the user then tilts the unit 30° above horizontal. Another 360° traversal around the room occurs. When this final round is done, there should be a reasonable 3D depiction of the

space. Figure 3-33 shows several rounds of snapshots taken during a 3D mapping exercise to demonstrate how the 3D model develops with each successive shot.

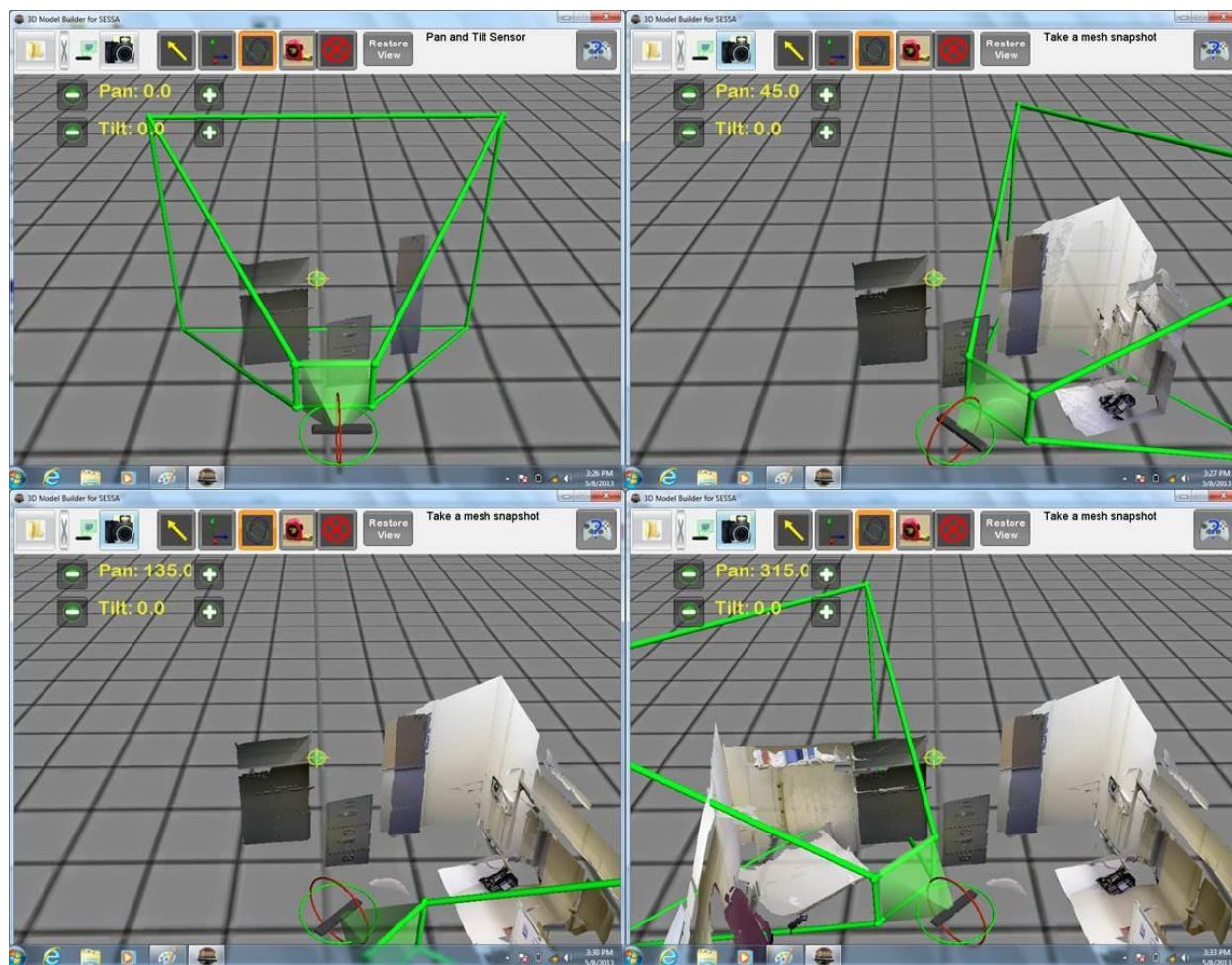


Figure 3-33. Snapshots with 3D Model Builder system

If more detail is desired in a particular part of the room, say a cluttered desk, the sensor can be kept at that location and several snapshots taken. Each additional snapshot provides another set of data that the model processes to fill in detail. The 3D Model Builder software is also trying to fit planes, such as walls, floors, ceilings, cabinets, etc. This makes the measurement capability more robust as well.

When taking measurements with the 3D scene, the user should be familiar with the 3D controls to pan and zoom around the room. Care must be taken to place the red and blue dots accurately at the two end points to be measured. The user needs to make sure they are actually on the surface they want to measure and not some surface slightly behind the one of interest. So rotating around the scene should help pinpoint the location. Once a red and blue icon is placed on the 3D map the software displays the measurement in the upper right area of the window, as shown in Figure 3-34.



Figure 3-34. Measuring in the 3D Model Builder system

The horizontal translation window looks like what is shown in Figure 3-35. It is this window that the user will input the height of the base of the tripod mount. If the user is going to integrate imagery in a large room the x, y offset help perform the off-set. This function can be used to build multiple rooms in a building as well, by translating the tripod location according to the estimated x, y offset between the tripod setups in adjacent rooms.

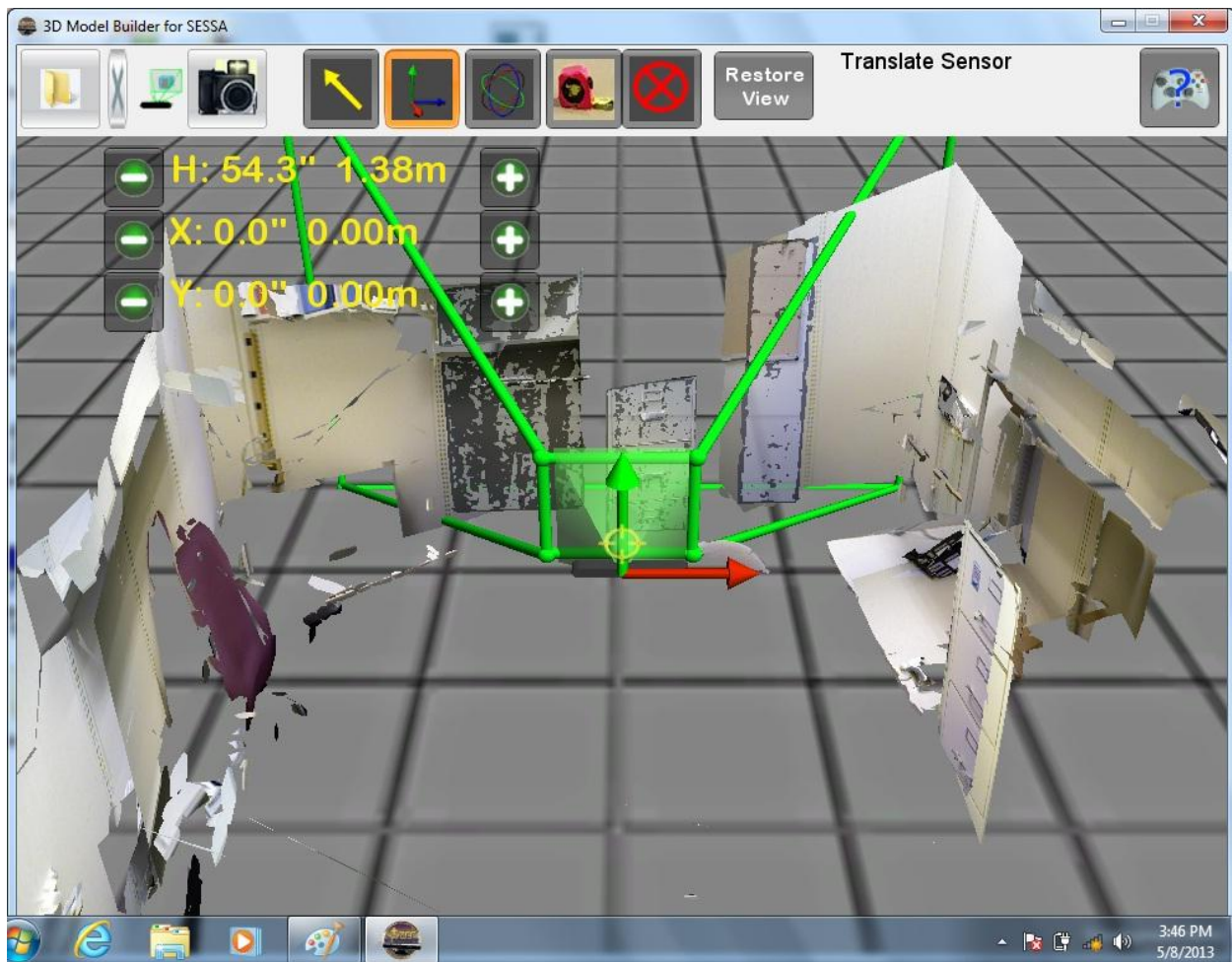


Figure 3-35. Translation window for 3D Model Builder system

The user can save the 3D map and revisit it at a later time. The file icon has a save button. The save pop-up window looks like what is shown in Figure 3-36. The last snapshot taken in the 3D scene creation is used as an identifier when scrolling through existing saved 3D models.

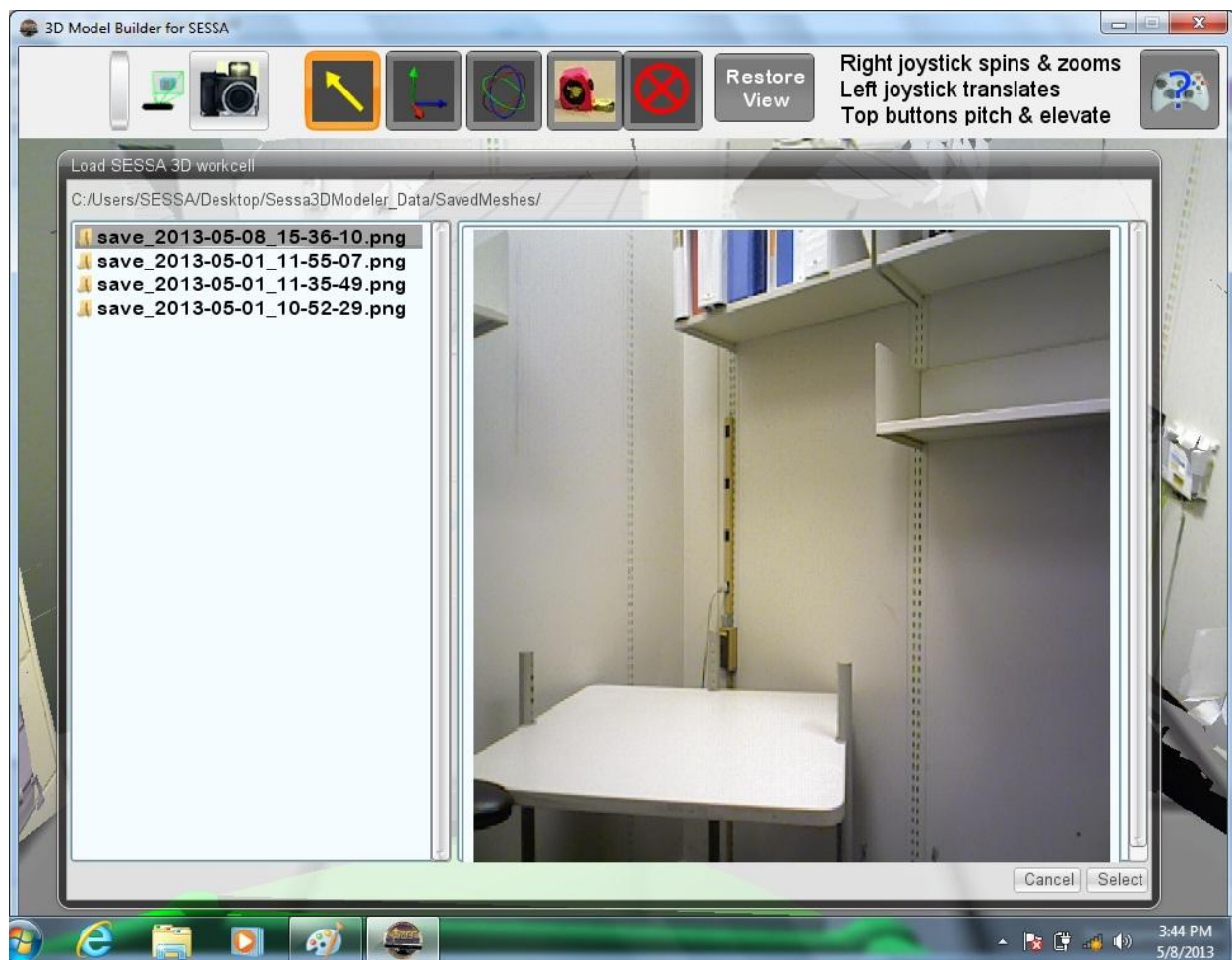


Figure 3-36. Saving a 3D Model Builder scene

ACRONYMS

ASD(R&E)	Assistant Secretary of Defense for Research and Engineering
BROOM	Building Restoration Operations Optimization Model
DFSC	Defense Forensic Science Center
DoD	Department of Defense
DoJ	Department of Justice
GB	Gigabytes
GIS	Geographical Information System
GPU	Graphics Processing Unit
IP	Internet Protocol
MB	Megabytes
MCIO	Military Criminal Investigation Organizations
MP	Mega Pixels
NCIS	Naval Criminal Investigative Service
PC	Personal Computer
PDF	Portable Document Format
RAM	Random-Access Memory
RF	Rapid Fielding
SESSA	Site Exploitation System for Situational Awareness
SLAM	Simultaneous Localization And Mapping
SNL	Sandia National Laboratories
SQL	Structured Query Language
SSE	Sensitive Site Exploitation
URL	Uniform Resource Locator
USACID	U.S. Army Criminal Investigation Division
USACIL	United States Army Criminal Investigation Laboratory
USAFOSI	U.S. Air Force Office of Special Investigations
USB	Universal Serial Bus

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